Washer for 75,000 c.f.m. forming part of "Visco" Ventilating Plant for Metal Room of S. Wales Steel Co., view shows inlet side.

VISCO

AIR CONDITIONING & FUME REMOVAL FOR STEELWORKS

Specialists in Industrial Ventilation and Air Conditioning, we have designed, manufactured and installed equipment for practically every industry. Recent installations include :—Air Conditioning Plant for hospitals, food factories, laboratories, electrical equipment and chemical works; Ventilating and Fume Removal Plants for steelworks, chromium plating works and many other types of factory. Where a constant supply of filtered air of specified temperature and humidity, irrespective of outside conditions, is required, as in chemical and food factories and laboratories, "Visco" equipment is installed.

FILTERS FOR VERY DUSTY PLACES

For most ventilating and air conditioning schemes our standard all-metal panel type filter is generally preferred. Where the dust load is exceptionally heavy, we recommend our "Reciprojet" Automatic Dust Cleaning Air Filter having automatic operation, two-stage filtration and positive cleaning of the filter cells by full bore reciprocating oil jets. This filter is specially suitable for the ventilation of electrical machinery in steelworks.

"Visco" standard oil-wetted Air Filter. These units can be built up to deal with any volume of air required.

We are at your service for a complete Air Conditioning installation or the supply of a single component.

VISCO ENGINEERING CO. LTD. STAFFORD RD. CROYDON

THE ENGINEER

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts: correspondents are therefore requested to keep copies.

SUBSCRIPTIONS

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF DURHAM

[KING'S COLLEGE, NEWCASTLE UPON TYNE

LECTURESHIP IN MECHANICAL ENGINEERING

The Council of King's College invite applications for a LECTURESHIP IN MECHANICAL ENGINEERING.

Applicants should hold an Honours Degree in Engineering and have had some professional experience since graduation. Preference will be given to candidates with an interest in " theory of machines " who are prepared to advance that subject by teaching and research. The Lecturer will also be required to take some part in the teaching of other branches of mechanical engineering.

The salary scale rises by annual increments of £50 to a maximum of £1100 and the commencing salary will be fixed at a suitable point on the scale in accordance with the qualifications and experience of the successful applicant. Family allowance and F.S.S.U.

Twelve copies of application, together with the names of three persons to whom reference may be made, should be submitted not later than 30th November to the undersigned, from whom further particulars may be obtained.

G. R. HANSON,
E6510 Registrar of King's College.

SOUTH SHIELDS EDUCATION AUTHORITY

MARINE AND TECHNICAL COLLEGE

Principal :
J. HARGREAVES, M.A., Ph.D., (Cantab.)

DEPARTMENT OF MECHANICAL AND MARINE ENGINEERING

ASSISTANT LECTURER

Applications are invited, for duty from January, 1955, of an ASSISTANT LECTURER in the Department of Mechanical and Marine Engineering. Candidates should hold a Degree in Engineering, or equivalent qualification, or the City and Guilds Certificate in Machine Shop Engineering or other engineering craft. Candidates should also have had adequate industrial experience. Salary for the post will be in accordance with the Burnham Scale for Grade A Assistants, viz., £450–£18–£725, per annum plus Degree and training allowances in appropriate cases. The initial salary will depend on previous industrial and teaching service.

Application forms, obtainable from the undersigned, Education Office, Westoe Village, South Shields, must be completed and returned to the Principal of the College not later than the 20th November, 1954.

A. J. W. JEFFERY,
E6443 Director of Education.

COUNTY BOROUGH OF ROTHERHAM

EDUCATION COMMITTEE

ROTHERHAM TECHNICAL COLLEGE

Principal : G. E. COOKE, M.A., A.M.I.C.E.

ASSISTANT (GRADE A)

Applications are invited for appointment as ASSISTANT (Grade A) to teach engineering workshop subjects, including fitting and bench work, together with some machine shop instruction.

Applicants should have had both industrial and teaching experience and preferably hold a City and Guilds Certificate in Machine Shop Engineering.

Salary will be in accordance with the Burnham Technical Award, 1954, the basic scale being £450 to £725 per annum, with increments for approved experience.

Application forms may be obtained from the undersigned, to whom they should be returned within two weeks of the appearance of this advertisement.

R. BLOOMER,
Director of Education.
Education Offices,
Rotherham. E6403

ROYAL TECHNICAL COLLEGE, SALFORD

Principal : P. F. R. VENABLES, Ph.D., B.Sc., F.R.I.C.

MECHANICAL ENGINEERING DEPARTMENT

ASSISTANT, GRADE B

Applications are invited for the post of ASSISTANT, Grade B, in the Mechanical Engineering Department. Applicants should hold an Engineering Degree and/or professional qualifications and should have had sound industrial and some teaching experience.

The successful candidate will be required to teach general mechanical engineering subjects to Ordinary National Certificate standard and to offer one or more subjects to Higher National Certificate standard.

Forms of application and further particulars of the post may be obtained from the Principal, Royal Technical College, Salford, 5, to whom completed forms should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
E6435 Clerk to the Governors.

PUBLIC APPOINTMENTS

SURREY EDUCATION COMMITTEE

KINGSTON TECHNICAL COLLEGE

FASSETT ROAD, KINGSTON-UPON-THAMES

(AMENDED ADVERTISEMENT)

HEAD OF THE ENGINEERING DEPARTMENT

Applications are invited for the post of HEAD OF THE ENGINEERING DEPARTMENT.

Candidates should possess a good Honours Degree. Teaching and industrial experience is essential, research experience desirable. Salary, Burnham Scale for Grade IV, £1365 by £25 to £1515, or Grade V, £1515 by £25 to £1665, Head of Department, plus London allowance £36 or £48, according to qualifications and experience.

Applications from candidates in reply to the previous advertisement will be considered on receipt of a note to this effect.

Further particulars and application forms obtainable on receipt of stamped, addressed envelope from the Principal. Completed forms to be returned not later than 4th December.

KINGSTON TECHNICAL COLLEGE
FASSETT ROAD, KINGSTON-UPON-THAMES

LECTURER IN AERONAUTICS

Applications are invited for the post of LECTURER in AERONAUTICS in the Engineering Department. The appointment is for a specialist in aerodynamics. Applicants should be Graduates with appropriate industrial experience. Teaching experience desirable. Salary scale £965 by £25 to £1065 plus London allowance (£36–£48, according to age).

Further particulars and application forms obtainable (on receipt of stamped, addressed envelope) from the Principal. Completed forms to be returned as soon as possible. E6378

CITY OF WAKEFIELD EDUCATION COMMITTEE

TECHNICAL COLLEGE

Principal :
G. N. BLAIR, M.C., B.Com., A.C.I.S., F.I.I.A.

APPOINTMENT OF TWO FULL-TIME ASSISTANTS (GRADE A)

Applications are invited for two FULL-TIME ASSISTANT LECTURERS, Grade A, in the Department of Engineering and Mining at this College.

(1) Graduate or equivalent to be primarily concerned with the teaching of mathematics to the A1 stage of Higher National Certificate in Mechanical Engineering.

(2) Suitably qualified person to teach mechanical engineering subjects to Ordinary National Certificate standard.

Salary in accordance with Grade A scale of the Burnham Technical Report, with allowances for Degree, training and industrial experience. Duties to commence as soon as possible.

C. L. BERRY,
Director of Education.
Education Office,
27, King Street,
Wakefield. E6472

KENT EDUCATION COMMITTEE

DOVER TECHNICAL COLLEGE

FULL-TIME TEACHER OF MATHEMATICS AND MECHANICAL ENGINEERING SCIENCE SUBJECTS

Required, January next, FULL-TIME TEACHER OF MATHEMATICS AND MECHANICAL ENGINEERING SCIENCE SUBJECTS up to and including Ordinary National Certificate final year standard. Ability also to teach Engineering Drawing and Physics an advantage. Applicants should possess either a Degree in Engineering, Graduate Membership of the Institution of Mechanical Engineers, or the Higher National Certificate in Mechanical Engineering. Salary, Grade B Burnham Scale, £525 by £25 to £820, with possible initial increments for industrial experience.—Apply immediately, stating age, education, training and industrial and/or teaching experience, together with the names of two referees to the Principal, Technical College, Ladywell, Dover. E6430

CIVIL SERVICE COMMISSION

H.M. DOCKYARD TECHNICAL COLLEGES

ASSISTANTS, GRADE A AND GRADE B

The Civil Service Commissioners invite applications from MEN for permanent appointments (22 Science and 3 Arts), commencing as soon as possible. Candidates must have a University Degree (or appropriate qualification). Qualifications in mathematics, physics, chemistry or engineering (electrical or mechanical), are required for the Science Posts and candidates for the Arts vacancies must be qualified to teach one or more of the following subjects :—English, French, certain amount of modern history, economics, current affairs. Burnham scales for Technical Colleges apply ; posts are pensionable under C.S. Superannuation Acts on non-contributory basis.—Details and application forms from Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 4391/54. Completed forms must reach him by 29th November, 1954. E6457

PUBLIC APPOINTMENTS

MONMOUTHSHIRE EDUCATION COMMITTEE

THE TECHNICAL COLLEGE OF MONMOUTHSHIRE, CRUMLIN

LECTURER

A LECTURER in Electrical Engineering is required at the above College from 1st January, 1955, or as soon as possible afterwards. Candidates must possess good academic qualifications in electrical engineering and have had wide industrial experience. Research and teaching experience would be regarded as added qualifications. Salary will be in accordance with the Burnham Scale for Lecturers in Technical Colleges, viz., £965 by £25 to £1065 per annum.

Further particulars and forms of application obtainable from the undersigned, must be returned not later than 30th November, 1954.

C. E. GITTINS,
Director of Education.
County Hall,
Newport, Mon. E6480

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

WORKSHOP INSTRUCTOR

Applications are invited for a post as WORKSHOP INSTRUCTOR. Duties will commence as from 1st January, 1955, or as soon as possible thereafter.

Candidates should hold a City and Guilds Certificate in Machine Shop Engineering and have practical experience in industry and in teaching. Graduate or Associate Membership of a professional Institution will be an advantage. Salary in accordance with the Burnham Technical Scale for Assistants, Grade A.

Further particulars and application form will be sent by the undersigned on receipt of a stamped, addressed foolscap envelope. Applications should be sent in to reach the undersigned not later than Tuesday, 30th November, 1954. Applications not on the form provided will be disregarded.

E. C. SMITH,
Principal.
5th November, 1954. E6500

NORTH WESTERN GAS BOARD

TRAINEE INDUSTRIAL GAS ENGINEERS

Applications are invited from Junior Draughtsmen, ENGINEERS or CHEMISTS possessing a University Degree, the Ordinary or Higher Certificate in Mechanical Engineering, or equivalent qualifications, for pensionable positions as TRAINEES in the industrial gas departments of the Central Lancashire, East Lancashire, Liverpool, Manchester, North Cheshire, Preston, South Lancashire and Wirral Groups. These departments are responsible for the development of the use of town's gas in industry and for central heating, steam raising and other processes.

Some experience in heat process calculations would be an advantage, but training and guidance would be given.

The work is primarily of a technical nature and is of wide scope and interest due to the increasing demand for fuel technologists, both inside and outside the industry.

The salary will be dependent upon qualifications and experience, and will be within Grades A.P.T. 5/6 (£500–£610 per annum), with prospects of promotion.

Detailed applications, stating the Group(s) preferred, and giving the names of two referees, should reach the Secretary, N.W.G.B., 60, Whitworth Street, Manchester, 1, within 14 days. E6478

ST. PANCRAS BOROUGH COUNCIL

BOROUGH ENGINEER AND SURVEYOR'S DEPARTMENT

APPOINTMENTS

Applications invited for following appointments in Borough Engineer and Surveyor's Department :—

(a) TECHNICAL ASSISTANT. A.P.T. Grades I–IV (£490–£625). Commencing salary according to qualifications and experience.

(b) TWO JUNIOR ASSISTANTS (one permanent and one temporary), in drawing-office. General Division (£190–£470, commencing salary according to age). Applicants should have completed National Service.

London weighting allowance payable according to age. No housing. Applications, with full details of qualifications and experience, and names of three referees, to reach undersigned by 20th November.

State whether related to any member or senior officer of Council.

R. C. E. AUSTIN,
Town Clerk.
St. Pancras Town Hall,
Euston Road, London, N.W.1. E6400

COUNTY BOROUGH OF EAST HAM

ENGINEERING ASSISTANT GRADE V

ENGINEERING ASSISTANT, Grade V, £620–£670.

London Weighting is paid in addition. Salary in excess of the minimum may be paid according to qualifications and experience.

A subsistence allowance may be granted over a reasonable period to the person appointed if unable to obtain suitable housing accommodation, necessitating the maintenance of two homes.

Further details and application forms returnable by 26th November, 1954, from the Town Clerk, Town Hall, East Ham, E.6. E6493

PUBLIC APPOINTMENTS

HER MAJESTY'S COLONIAL SERVICE

[NORTHERN RHODESIA]

ASSISTANT DIRECTOR OF PUBLIC WORKS (ROADS)

Applications are invited for the following ASSISTANT DIRECTOR OF PUBLIC WORKS (ROADS), Northern Rhodesia.

Duties : control of Roads Branch of the Works Department under direction of Commissioner of Works, including supervision of construction, maintenance of roads and bridges by department and contract labour.

Appointment on contract/gratuity terms. Emoluments £2231 p.a., plus substantial gratuity on satisfactory completion of contract. Free passages, limited free medical attention, generous leave.

Candidates, who should be between 40–50 years of age, must hold a recognised University Degree or Diploma carrying exemption from the Final Parts I and II of the A.M.I.C.E. examinations, or A.M.I.C.E. They should have at least 10 years' experience in modern road construction methods, particularly concerning thin flexible pavements, considerable experience in the application of soil analysis technique for design of gravel and natural soil bases and sub-bases ; bridge and culvert design ; organisation of large road construction and maintenance schemes using modern plant and equipment.

Further details on application to the Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, giving full details of age, qualifications and experience, and quote reference BCD/112/3/011/D4. Closing date for receipt of initial inquiries 14th December, 1954.

THE WATER RESEARCH ASSOCIATION

DIRECTOR OF RESEARCH

The Water Research Association, recently constituted by the water supply undertakings of Great Britain for the purpose of initiating and carrying out research, both applied and fundamental, into problems in the water supply industry, invites applications for the post of DIRECTOR OF RESEARCH at a salary within the range of £1750 to £2000 per annum (with superannuation F.S.S.U.).

Candidates should give full details of their academic qualifications, training, experience and evidence of their ability to build up and direct a research laboratory and staff.—Applications should be sent to the Secretary at 34, Park Street, London, W.1, marked " Director of Research " on the outside of the envelope, in the top left-hand corner, on or before the 26th November, 1954.

DESIGNING DRAUGHTSMAN, GRADE

EAST AFRICAN RAILWAYS AND HARBOURS ADMINISTRATION

DESIGNING DRAUGHTSMAN, Grade required by the East African Railways and Harbours Administration for one tour of 40/48 months with prospect of permanency. Salary scale (tax free) temporary allowance of 35 per cent. of salary, rising to £1012 a year. Free quarters or an allowance in lieu. Outfit allowance £30, free passages, leave on full salary. Candidates must have served full apprenticeship to locomotive or mechanical engineering, and have had mechanical experience with British Railways or a locomotive building firm, must have at least three years' drawing-office experience in the design of locomotives and their components, and must also have experience of mechanical handling equipment in use at port or railway depots.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2A/30519/EH.

DEPUTY PRINCIPAL

GOVERNMENT TECHNICAL INSTITUTE, BRITISH GUIANA

DEPUTY PRINCIPAL required by the Government Technical Institute, British Guiana, for appointment on contract for three years in the first instance. Salary equivalent to £1050 a year (including temporary allowance of £50 a year). Gratuity at the rate of £225 a year. Free passages, liberal leave on full salary. Candidates must hold a C. and G. Technological Certificate or H.N.C. in Electrical or Mechanical Engineering, or a similar qualification, and have had wide industrial and teaching experience. They must be able to undertake lectures at a level up to the standard of the H.N.C. and the examinations for the Professional Institutions.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2A/30288/EH.

COUNTY BOROUGH OF READ

WATER DEPARTMENT

APPOINTMENT OF JUNIOR ENGINEERING ASSISTANT

Applications are invited for the above appointment. Salary A.P.T., Grades II-III (£2 according to qualifications and experience. Joint Council conditions apply. Appointment subject to (a) passing of a medical examination, superannuation purposes, and (b) determination by one month's notice.

Applications, stating age, qualifications, experience, with copies of recent testimonials, names of two referees, should be sent to the Engineer and Manager, 16/20, The Forbury, by 9th December, 1954.

THE ENGINEER

NOVEMBER 12, 1954

"Comet" Court of Inquiry

THE discussion of technical evidence at the court of inquiry into the "Comet" disasters continues at Church Hall, Westminster. On Tuesday of last week, Sir Arnold Hall stated that if a thicker gauge skin was used and there was some strengthening of the fuselage and wings, the aircraft could go back into service. Lord Brabazon, chairman of the Air Registration Board, referred to the decisions made in connection with the airworthiness of the "Comet" and stated that if every type of aircraft were grounded that had experienced an unexplained accident, there would scarcely be a machine in the air. He later pleaded that it was metallurgy, not aeronautics, that was in the dock. Later in the week, Dr. Walker, of the Royal Aircraft Establishment, maintained that without knowledge of the disasters and based solely on the structural tests carried out, the R.A.E. would probably not have agreed to the aircraft flying beyond 2700 hours. Based on that figure, it would have regarded the Elba "Comet" as definitely in danger and the Naples "Comet" as either in danger or approaching it. Dr. Walker then went on to suggest, with regard to fatigue testing, that there had been a lack of co-operation between the R.A.E. and the makers of the craft when they were first made. On Monday last, the court again considered the theory advanced by Mr. Jablonsky that the "Redux" bonding had failed because of the expansion/contraction cycle of the skin. He maintained that in all three "Comet" disasters the aircraft had been subjected to tropical heat when the adhesive strength could drop by 50 per cent. He agreed with Sir Arnold Hall that the cause of the disaster was the bursting of the cabin due to an inherent weakness, but did not entirely accept the influence of fatigue in the metal alone as a primary cause of that explosion.

Central Research Laboratory of the Permanent Magnet Association

LAST Monday we visited the central research laboratory of the Permanent Magnet Association, Brown Street, Sheffield, to see the recently completed extensions to the laboratory building. It may be recalled that for many years before the existence of the present building the research effort of the Permanent Magnet Association was carried out on a co-operative basis by investigations in the works laboratories of the members. Centralised research by the P.M.A. dates back to 1941, when accommodation was made available temporarily in the Physics Department of the University of Sheffield. With the completion of the first storey of the present building in 1946 facilities were provided for pilot manufacture and treatment of magnet castings; laboratories were equipped for chemical analysis and metallographic and physical work; there was also a workshop for the making of laboratory instruments and apparatus. Office space and library and conference facilities were, however, inadequate and a second storey was, therefore, built. Our tour of the establishment showed us how it is equipped and organised, under its director of research, Mr. J. E. Gould, to work on the development of improved magnetic alloys and to study the composition and heat treatment of alloys, with a view to improving the quality and yield of manufacturing processes. On the ground floor there is a pilot plant comprising a foundry, with a 35kVA high-frequency melting furnace capable of making ingots of up to 20 lb, and there is moulding and core-making plant for the manufacture of castings. The adjoining workshop is equipped for fettling, grinding and general machining. Electric furnaces are also installed for the heat treatment of samples up to 1350 deg. Cent. The main heat-treatment room is on the first floor where there are a number of electric furnaces, some of which are equipped with electronic controllers and recorders. The magnetic and mechanical properties of materials are measured and investigated in the physics laboratory on the ground floor. Here the apparatus includes a Sucksmith balance for determining the magnetisation of specimens at various temperatures. An improved and direct method has been developed for the ballistic testing of permanent magnets. A torque magnetometer has been devised for measuring the rotational hysteresis of specimens, the practical importance of which is growing with the increased interest in hysteresis motors as components of servo and gyro systems. Another useful line of investigation being carried out in the physics laboratory is concerned with the effect of low temperature on the stability of permanent magnets and we witnessed a demonstration which showed that a specimen of "Alcomax III" underwent a loss in magnetisation of 1·2 per cent on being cooled from room temperature to −75 deg. Cent. The general task of the chemical laboratory is to make routine analyses of casts and of raw materials used in the foundry and to evolve new methods for analysing complex magnetic alloys. Accordingly the laboratory is well equipped to practice modern techniques of gravimetric, volumetric and absorptiometric analysis. For the metallurgical examination of samples the equipment includes a photographic microscope. On the second floor there is a store-room and a spare laboratory, providing some space for further expansion.

Safety in Farm Machinery Operation

AT a meeting of the Institution of British Agricultural Engineers, which was held in London on Tuesday last, there was a discussion on safety in the operation of farm machinery. The subject was introduced by Mr. J. C. Gough, chief machinery inspector of the Ministry of Agriculture, who presented some statistics of accidents on farms in the years 1949–1952. The figures showed that in the fatal and non-fatal accidents arising from the use of machinery, the majority occurred with tractors. Mr. Gough said that many of these accidents were associated with the actual movement of tractors, rather than with particular working parts, such as power take-off shafts. He wondered if anything could be done in the way of design to improve the stability of agricultural tractors. Mr. H. E. Ashfield, who spoke from the machinery designer's and maker's point of view, suggested that it was impossible for a manufacturer to say just at what angle a tractor could be safely operated. He felt, however, that there were several ways in which manufacturers could contribute to the safer operation of farm machinery. Among them he mentioned the provision of guards around belt pulleys and over power take-off shafts and also the provision of a hand-operated clutch at the back of a tractor. He thought it should be borne in mind, however, that there were some implements fitted to tractors which did not always assist their safe operation. Another speaker was Mr. B. Ungerson, an industrial psychologist, who recalled the claim that accident proneness, though largely inherent, could usually be overcome by instruction and training. He claimed also that good industrial relations led to a reduction in the accident rate. Mr. D. R. Bomford, who is an engineer and a farmer, said that farm machinery should be made as safe as was reasonably possible, but he thought that farm machinery could never be made absolutely safe! The problem of safety in operation, he believed, was almost entirely an educational one. In summing up the discussion, the president, Mr. D. P. Ransome, expressed the opinion that agricultural machinery was probably the most dangerous class of machinery produced. But, Mr. Ransome said, if legislation was introduced, along the lines of the Factories Acts, it would be difficult to enforce it in view of the extensive and remote areas that would have to be covered by the necessary inspectorate.

Helicopter Airworthiness Certificate

THE Air Registration Board has issued a full Certificate of Airworthiness for the Westland "S–55" helicopter, following the successful completion of all performance trials and a period of intensive operating experience in the hands of an independent operator. This is the first British-built helicopter now in production capable of carrying eight passengers and their baggage, in addition to a crew of two, for which a full Certificate of Airworthiness has been issued. The certificate covers all categories of operation: public transport for passengers, public transport for mails, public transport for goods, private flying, aerial survey work, demonstration, and crew familiarisation. At the moment, the "S–55" is the biggest British helicopter now being delivered to the three Services and to operators overseas. It has only one lift rotor. Although the machine is powered by a Pratt and Whitney "Wasp" engine it may later be replaced by a British engine now under development. It has all-metal main and tail rotor blades which give maximum durability in all climates, and the main rotor is so positioned that while it is still turning passengers may embark and disembark in safety, and military operations can be conducted in jungle and scrub without risk of damage to the blades. The all-up weight of the aircraft is 7500 lb; it has a maximum speed of 110 m.p.h. and a normal cruising speed of 90 m.p.h. Manufacture of the prototype components of the Westland "S–55" was started in 1951, and since the first production model was delivered to the French Navy nearly fifty machines have been built and delivered, either to the Forces or to civilian operators. Five "S–55s" were recently delivered to British and Norwegian whaling companies and will operate from factory ships during the forthcoming whaling season. An order approaching 100 of the military version has been placed by the Ministry of Supply and some twenty of these have already been delivered. The issue of this certificate coincides with the delivery of the first of two machines to British European Airways, which is to operate a helicopter service from London Airport and Waterloo starting next April.

International Committee on Terminology

A COMMITTEE consisting of representatives of nine nations has recently concluded a session at Vienna, at which industrial terminology has been discussed. The meeting was held under the ægis of the International Organisation for Standardisation, and Dr. L. Hartshorn, Professor R. O. Kapp, and Mr. Gordon Weston, who is the technical director of the British Standards Institution, attended as the representatives of the United Kingdom. During the meeting, it was explained that the various committees of the International Standards Organisation were preparing standard terms in their respective fields in the hope that, ultimately, what would amount to a series of multilingual vocabularies covering the whole industrial field might become available. The Vienna meeting was the second which the terminology committee has held. The committee's particular task is that of determining certain general principles for the preparation of the glossaries. Those principles, it has been stated, will bear on the choice and the formulation of standard terms and definitions, on certain aspects of presentation such as indexing, and on the procedure to be followed in the preparation of standard terms, glossaries, vocabularies and dictionaries by national and international bodies.

Plane Frame for Testing Structures

By J. C. CHAPMAN,* Ph.D., A.M.I.C.E., and S. R. SPARKES,* Ph.D., M.Sc., A.M.I.C.E., M.I.Struct.E.

This note describes an internally equilibrated two-dimensional testing frame which is in use at Imperial College. The frame is designed to apply loads up to a maximum of 100 tons. Structures having overall dimensions up to 22ft by 8ft can be accommodated.

THE frame described was built primarily for a series of experiments on box girders, but the frame and loading appliances have also been designed so that they may be readily adapted for other structures. The frame is rectangular and welded throughout. The internal dimensions are 22ft by 8ft and the whole of this space is available for the structure under test (Fig. 1). The members of the frame are 22in by 12in "I"-sections with flanges 1in thick and ¾in webs. The central part of each horizontal member is reinforced by flange "cover plates," placed inside the flanges in order to avoid obstructing the outer surfaces. The webs are sufficiently thick to withstand a concentrated load of 100 tons at any point, and the stiffeners are intended only to stabilise the flanges. After fabrication of the four frame members but before they were joined at the corners, the outer surfaces of all flanges were machined to provide a true bearing surface. The end supports, which are bolted to the frame, are of light construction since they are required only to sustain the dead weight of the frame and specimen. Adjustment of level is provided by threaded bars which pass through the floor of the laboratory and serve as holding-down bolts.

The load is applied by hydraulic compression jacks mounted on the underside of the lower frame girder, and pressure is supplied by a variable-flow pump (Fig. 2) having a range of 0 lb to 6000 lb per square inch. Movement of the rams of the jacks under gravity is prevented by counterweights. The load from a jack is applied through a cylindrical bearing to a slotted cross girder, which in turn transmits the load to high-tensile steel bars passing through the slots (Fig. 3). The bars are loaded concentrically by means of a self-aligning anchorage (Fig. 4), consisting of a slotted cylindrical bearing in which the end of the bar is a sliding fit ; a 1in diameter pin passes through the cylinder and a hole in the bar, and thus direct tension only is transmitted to the bar. The full cross-section of the tension bars is 2¼in by 1in but they are reduced in section over most of their length in order that a measurement of their extension (by dial gauges placed on either side of the bar (Fig. 3)) should provide a means of measuring the load which they transmit. The bars are designed to carry 25 tons each and the extension over the measured length is then 0·14in. As the dial gauges measure to 1/10,000in, this provides a very sensitive load measuring device, one division on a gauge corresponding to a load of 40 lb. The vertical bars of ½in diameter (Fig. 2) support the cross girder during erection or in event of failure of the loading links, and they remain slack during loading.

The load is transmitted to the specimen through double-fork links and 1in diameter pins to bars which are bolted to the specimen. The loads are reacted on the upper side of the specimen by 2¼in by 1in bars, and adjustment of length is provided by double straps with holes drilled at 2in centres. The upper ends of the adjustable bars pass through self-aligning anchorages on the upper flanges of the top cross girders, which are supported on cylindrical rocker bearings. Safety bars, which are quite slack during loading, pass through the slots in the lower flanges of the upper cross girders, and the specimen itself is similarly supported during erection, and

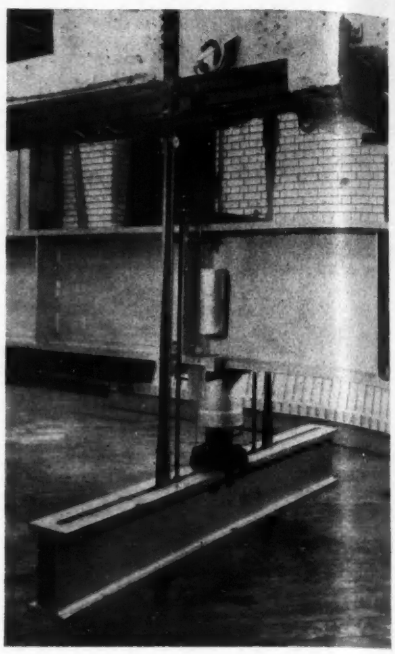

Fig. 3—Detail of loading system

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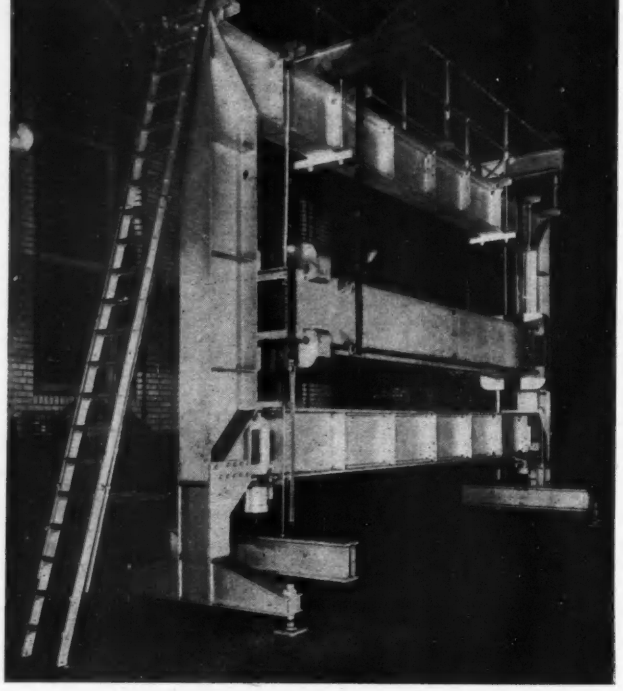

Fig. 1—The 100-ton loading frame accommodates structures up to 22ft by 8ft

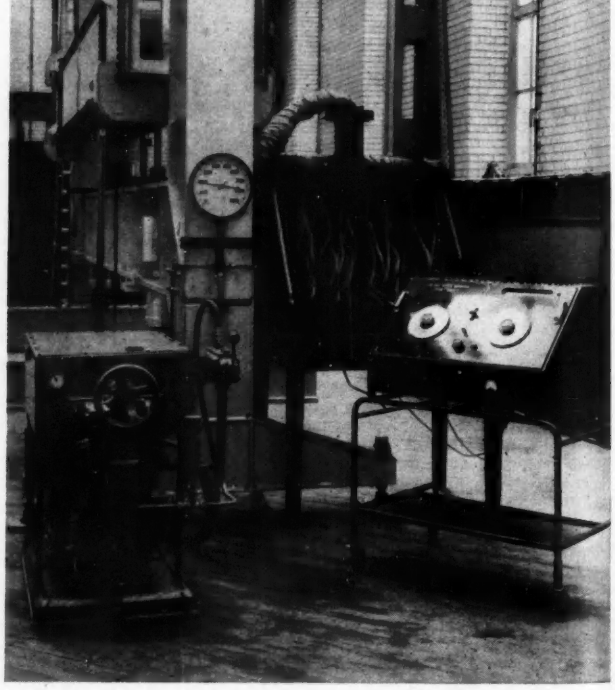

Fig. 2—Variable-flow pump and strain measuring equipment

against possible failure, by vertical hangers at either end.

All the tension links and shear pins are of Vibrac 77-ton steel having a yield point of 70 tons per square inch, and the welding of the frame is of the highest quality throughout. The maximum design load of 100 tons has been applied between the centres of the horizontal members, and the frame behaved elastically.

The tension links and fittings have been designed to be interchangeable with the

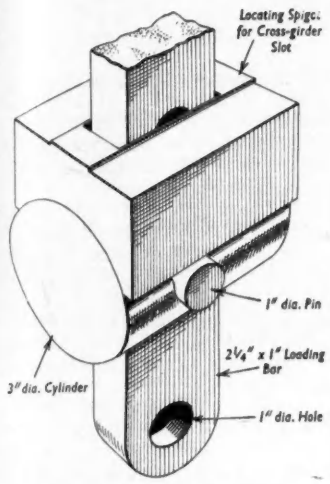

Fig. 4—Self-aligning anchorage

links of the space frame which was described earlier.* The parts are machined to close limits in order that bearing stresses should be evenly distributed and bending of the pins should be reduced to a minimum. All the linkages have been tested to 10 per cent overload without being overstrained.

The corners of the frame are of orthodox design with a single diagonal stiffening plate. The transmission of bending moment around such a corner is of some interest and strain measurements are being made in order to determine the distribution of stress near the corner. From purely statical considerations it would be supposed that the force in the diagonal plate was about $\sqrt{2}$ times the force in the flanges, but preliminary strain measure-

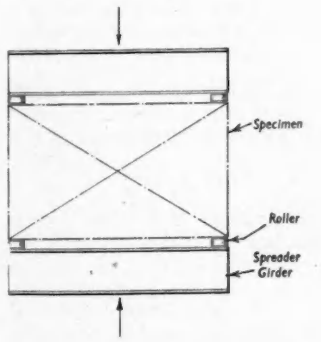

Fig. 5—Compressive loading system

ments show that the stress in the diagonal plate is much smaller than that in the inner flanges and diminishes to a very small value towards the outer corner. Clearly the web plays a large part in the transmission of bending moment, but the strains which have so far been recorded indicate that the design stress is not exceeded.

* "Frame for Testing Structures." B. H. Falconer and S. R. Sparkes. THE ENGINEER, December 26, 1952.

One purpose of the essentially tensile loading arrangement is to ensure that a specimen is loaded by purely vertical forces. Where the specimen is a beam to which bending moments are to be applied, it is desirable that there should be no horizontal restraint, and this is very difficult to achieve where the loads are applied by compressive forces. In that event the load is normally applied through rollers, and even where hardened steel is used some indentation of the pad on which the roller rests is bound to occur, and this necessarily results in unwanted horizontal forces being applied to the specimen. Where the loads are applied through long tension bars as in the present loading frame, the horizontal force is only that which is due to the very small horizontal component of force in the hangers consequent upon the elastic elongation or shortening of the specimen. This force is extremely small and could be calculated if required. Even if rollers were

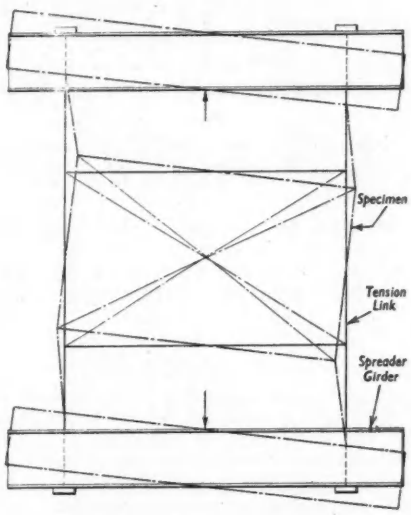

Fig. 6—Tensile loading system

sufficiently effective in the longitudinal direction, they would give rise to unwanted restraint in the transverse direction, and the tension loading also avoids this difficulty.

A further disadvantage of loading in compression is that one point on the specimen must remain fixed in order that the system should be longitudinally stable, and since this point can seldom be on the axis of symmetry the lengths of the lever arms, and hence the applied moments, are likely to change appreciably, due to elastic deformations of the specimen. Where tension loading is used it is unnecessary to provide a fixed point, since the system is inherently stable and the relative dimensional changes in the loading system due to elastic deformations of the specimen are then reduced to a minimum.

Where it is required to apply bending moment to a wide specimen such as a box girder it is usually necessary to apply the load through cross girders supported only at their centre points (Fig. 5) in order that small dimensional inaccuracies in the specimen should not cause unwanted torsional forces. A compressive loading system is then, at best, statically stable only after a small load has been applied, and becomes elastically unstable when the "critical" load of the system is reached. There is also likely to be great difficulty in arranging the system prior to loading. The tension system is stable under zero load and there is no difficulty in setting up; furthermore, the load can be returned completely to zero after each loading cycle without dislocating the system.

Although all four cross girders are supported on rocker bearings, the system described is stable, since a small tilting of the specimen would throw the upper and lower loading links out of alignment, and the tension in the bars then provides a restoring couple (Fig. 6). This would not be the case if the upward and downward loading forks were all attached at the same level to a specimen; the system would then be in neutral equilibrium, and in order to achieve stability it would be necessary to replace one of the rockers by a flat bearing.

ACKNOWLEDGMENT

The frame was designed for investigations at Imperial College, undertaken for the British Shipbuilding Research Association.

Sea Water Tests on Titanium

COMMERCIALLY pure titanium has, in addition to a high strength-to-weight ratio, a notably good resistance to attack by a large number of chemicals. The apparent immunity of titanium to corrosion by sea water has been established, both in jet impingement and immersion tests. As Dr. Dorey[1] pointed out in his presidential address to the Institute of Metals, the remarkable resistance of titanium, in the high-purity form or with small alloy additions, to severe attack by both hot and cold sea water has aroused the interest of the marine engineer. A paper by H. B. Bomberger, T. J. Cambourelis and G. E. Hutchinson[2] records additional information on titanium, and on a number of materials used as controls, which have been exposed since midsummer, 1948, to a marine environment at the Kure Beach test station of the International Nickel Company, Inc. Commercial titanium appeared to be completely unaffected in these tests. In long-time tests designed to show susceptibility to sea water immersion, erosion, crevice corrosion, contact with dissimilar metals, stress corrosion and corrosion fatigue, no noticeable effect was observed on titanium. It showed no loss of weight when subjected for thirty days to the action of a submerged jet of sea water containing 2·4 per cent by volume of entrained air at a velocity of 12ft per second and an average temperature of 23·5 deg. Cent. Specimens whirled in sea water at 30ft per second for sixty days suffered negligible attack. Titanium has an unusually high resistance to cavitation erosion. In tests for crevice corrosion, there was no evident attack on titanium in circumstances in which austenitic stainless steels were strongly affected. There was no difference in the endurance limit in sea water and in air, and tensile specimens of yield strength 46 tons per square inch were exposed under static loads of up to 35 tons per square inch for five years without sign of failure. In a marine atmosphere and in sea water tests, there were no indications that titanium suffered in any way as a result of being in contact with commonly used metals and alloys. Titanium coupled up to Inconel, silver and austenitic stainless steels had a negligible effect on the corrosion rates of these materials, but the rates of corrosion of Monel metal, copper, low-carbon steel and aluminium alloys were in some cases more than doubled. In employing titanium in structures subject to corrosion, the usual precautions will have to be taken to avoid incompatible combinations, but this further evidence confirms Dr. Dorey's view that the mechanical properties and corrosion resistance of titanium are of such a high order as to render it suitable for many applications in marine engineering. Its actual use must await the solution of problems associated with its economic production.

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Elementary Treatment of the Polyphase Induction Motor

By J. E. PARTON,* Ph.D., M.I.E.E. and O. K. GASHUS,* B.Sc.

The constant-flux theory of the induction motor gives torques which may be two or three times as great as actual torques and starting times which are only a fraction of the measured times. Here we discuss these errors and, for students, advocate the use of the approximate equivalent circuit for all calculations. This process gives reasonably near results, and it conforms to the usual form of circle diagram given to students.

THE use of the equivalent T-circuit, Fig. 1(*a*), for obtaining the performance equations of a polyphase induction motor operating under balanced, steady-state conditions, is well established, and the derivation of the circuit is given in most standard text-books.[1] Unnecessarily complicated formulæ arise from the T-circuit, and the establishment of the corresponding circle diagram requires a detailed knowledge of inversion and *loci* not usually possessed by engineering students.

For these reasons, it is often found convenient to ignore the voltage drop due to the flow of shunt current I_0 through the primary leakage impedance Z_1. This corresponds to misplacing the shunt admittance Y_0 across the supply as shown in Fig. 1(*b*), which is the approximate equivalent circuit.

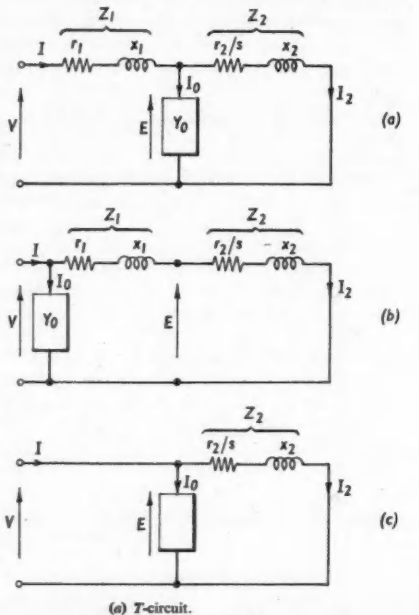
In both of these equivalent circuits, the back e.m.f., E induced in each phase of the primary winding by the useful air-gap flux per pole varies with the load current due to the voltage drop in the primary leakage impedance.

In the still simpler "constant-flux" analysis often given to students,[2,3] the useful air-gap flux is assumed to be constant, and the induced e.m.f., E is then always equal to the applied voltage V. This approach entirely ignores the presence of the primary leakage impedance which carries the full input current, and it corresponds to the use of the constant-flux circuit, Fig. 1(*c*).

Admittedly this gives a ready means of presenting to the student the mode of action of the induction motor, more particularly how the torque varies with the slip. Unless specifically counteracted, however, an impression is left with the student that the refinement of including the primary leakage impedance is in the nature of a 5 per cent correction. In fact, results calculated from the constant-flux theory can often be greater than the experimental values by 100 per cent or more. The magnitude of these errors does not appear to be widely appreciated, however, for problems based on the constant-flux theory are still often presented to students.

Some years ago, L. H. A. Carr[4] emphasised the desirability of using equivalent circuit and circle diagram solutions of the induction motor which are consistent with each other and the wisdom of this advice has been clearly demonstrated over several teaching years. For this reason, the approximate equivalent circuit, Fig. 1(*b*), is advocated for students; it avoids the complications of the T-circuit and the large errors of the constant-flux circuit. Also, it corresponds exactly to the form of the simple circle diagram, as it is usually given to students.[5] Values calculated from the approximate equivalent circuit are usually within a few per cent of those given by the T-circuit.

It is the object of this short article to compare performance equations derived from the constant-flux and approximate circuits so as to emphasise the errors arising from the use of the former. Analytical results will be compared to those measured experimentally upon a 3 h.p., three-phase induction motor, typical of those in many teaching laboratories.



(*a*) *T*-circuit.
(*b*) Approximate circuit.
(*c*) Constant-flux circuit.

Fig. 1—Equivalent single-phase circuits of a polyphase induction motor corrected for 1/1 turns ratio

Analytical Results

There are many different aspects of the operation of an induction motor which might be examined; two only will be given here, the torque-slip and starting time expressions.

Torque-Slip Relation.—For the constant-flux theory, this is easily obtained by considering Fig. 1(*c*). An m-phase, $2p$-pole induction motor fed at V volts per phase at an angular frequency $\omega(=2\pi f)$ has a torque

$$T=\frac{mpV^2}{2\omega x_2}\cdot\left(\frac{2as}{a^2+s^2}\right)\text{ newton-metres}\dagger \quad . \quad (1)$$

in which a is the ratio of rotor resistance to leakage reactance r_2/x_2, at standstill.

This has a maximum value

$$T_{max}=\frac{mpV^2}{2\omega x_2} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

which occurs at the slip

$$s_{max}=r_2/x_2=a \quad . \quad . \quad . \quad . \quad (3)$$

so that equation (1) is often written:

$$(T/T_{max})=2as/(a^2+s^2) \quad . \quad . \quad . \quad (4)$$

The corresponding equations obtained from the approximate equivalent circuit, Fig. 1(*b*) are,

$$T'=\frac{mpV^2}{2\omega x_2}\cdot\left[\frac{2as}{(a+bs)^2+(1+c)^2s^2}\right] \quad (5)$$

$$T'_{max}=\frac{mpV^2}{2\omega x_2}\cdot\Big/\left[b+\sqrt{b^2+(1+c)^2}\right] \quad (6)$$

$$s'_{max}=\frac{r_2}{\sqrt{[r_1^2+(x_1+x_2)^2]}}=\frac{a}{\sqrt{[b^2+(1+c)^2]}} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and

$$T'/T'_{max}=\frac{2as[b+\sqrt{b^2+(1+c)^2}]}{(a+bs)^2+(1+c)^2s^2} \quad . \quad . \quad (8)$$

In these, $a=r_2/x_2$, $b=r_1/x_2$, $c=x_1/x_2$, and the prime indicates values obtained from the approximate circuit to distinguish them from those for the constant-flux circuit. These equations can be reduced to the first four by simply writing $b=c=0$.

It is interesting to note that as for the constant-flux theory, the maximum torque is independent of the rotor resistance (r_2 and a). So that a slipring motor in which x_2 is fixed and r_2 has various values (for instance by adjusting an external resistance) will have a family of torque-slip curves all with the same maximum values, but occurring at different speeds.

Before comparing these two sets of equations with experimental results, it is worth while noticing that by ignoring the primary resistance ($r_1=b=0$) and taking the simple case of equal primary and secondary leakage reactances $x_1=x_2$ and $c=1$, the maximum torque obtained from the constant-flux theory is exactly twice as large as that given by the approximate circuit. Likewise, the slip at which this maximum torque occurs is also twice as great in the former case.

Starting Time Equations.—A recent book by T. F. Wall[6] develops expressions for the accelerating and decelerating times for an unloaded induction motor on the basis of what is referred to as the "Kloss" formula, which is, in fact, equation (4) expressed a little differently.

Having an expression for the variation of torque with slip, and knowing the effective moment of inertia of the rotor, an expression can be developed for the time taken to accelerate (or decelerate) from slip s_1 to slip s_2.

Suppose $T=f(s)$ is an expression for the net torque allowing for friction and windage torque, and ω_m is the angular speed of the rotor in mechanical radians per second, then

$$s=\frac{\omega-p\omega_m}{\omega} \text{ and } \frac{ds}{dt}=-\frac{p}{\omega}\cdot\frac{d\omega_m}{dt}.$$

Thus if J is the moment of inertia

$$T=f(s)=J\frac{d\omega_m}{dt}=-\frac{\omega}{p}\cdot J\cdot\frac{ds}{dt}$$

is the equation of angular acceleration, and the time required is

$$t_{12}=J\cdot\frac{\omega}{p}\cdot\int_{s_2}^{s_1}\frac{ds}{f(s)} \quad . \quad . \quad . \quad . \quad (9)$$

For the constant-flux theory, $f(s)$ is given by equation (4) $T_{max}\cdot 2as/(a^2+s^2)$, ignoring friction and windage torque. Substituting this in equation (9) gives

$$t_{12}=\frac{\omega J}{p2T_{max}}\left[a.\ln\left(\frac{s_1}{s_2}\right)+\frac{1}{2a}(s_1^2-s_2^2)\right] \quad . \quad (10)$$

Similarly, for the approximate circuit, equation (8) gives

$$f(s)=T'_{max}\cdot\left[\frac{2as(b+d)}{a^2+2abs+s^2d^2}\right]$$

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† To convert to lb-ft units, if required, use the relation 550lb-ft =746 newton-metres.

‡ The symbol *ln* denotes natural logarithm

in which $d^2=b^2+(1+c)^2$ has been introduced for convenience. Substituting this in equation (9) gives

$$t'_{12}=\frac{\omega J}{p2T'_{max}}\cdot\frac{1}{(b+d)}\left[a.ln\left(\frac{s_1}{s_2}\right)+2b(s_1-s_2)+\frac{d^2}{2a}(s_1^2-s_2^2)\right] \quad . \; . \; . \quad (11)$$

Equation (11) will reduce to equation (10) on writing $b=0$, $c=0$, and $d=1$.

Expressions (10) and (11) are general so long as the correct slip limits s_1 and s_2 are inserted. The difference between these two expressions will be examined for the particular motor tested experimentally.

Experimental Results

The previous performance equations will be applied to an actual induction motor and the results compared with experimental figures.

The machine used was a 400V, three-phase, 50 c/s, six-pole induction motor with the following details.

Stator.—Normally delta connected, three separated phases were available for measurement, thirty-six slots, single-layer winding, eighteen coils of eighty turns per coil, coil pitch five slots (1–6), 480 turns per phase.

Rotor.—Single squirrel cage, forty-nine bars of rectangular section.

Parameters.—For the approximate circuit, Fig. 1(*b*). All measurements and tests were carried out with 100V across each phase of the stator winding, allowing steady state torque measurements to be made without overheating the stator.

$r_1=5{\cdot}59\Omega$ per phase by d.c. measurement.

$x_1=14{\cdot}3\Omega$ per phase by usual calculations.[7]

The primary leakage impedance was checked by measurements on the stator winding made when the rotor was removed. The value obtained gave $Z_1=(6{\cdot}3+j15{\cdot}1)\Omega$ per phase, which is sufficiently close to justify the use of the former.

No-load admittance at 100V per phase, $Y_0=(1{\cdot}36-j4{\cdot}02)$ mʊ per phase.

Standstill impedance at 100V per phase, $Z_s=(11{\cdot}69+j32{\cdot}69)\Omega$ per phase.

As $Z_s=Z_0(Z_1+Z_2)/(Z_0+Z_1+Z_2)$, the combined impedance (Z_1+Z_2) can be determined; this gives

$$(Z_1+Z_2)=(13{\cdot}83+j38{\cdot}31)\Omega \text{ per phase.}$$

Subtracting the value of Z_1 from this gives the equivalent secondary leakage impedance as

$$Z_2=(8{\cdot}24+j24{\cdot}01)\Omega \text{ per phase.}$$

The non-dimensional parameters are :

$a=0{\cdot}3432$, $b=0{\cdot}2328$, $c=0{\cdot}5956$, $d=1{\cdot}6125$ and $(b+d)=1{\cdot}8453$.

Torque-Slip Curves

Constant-Flux Theory, Fig. 1(*c*).—From equation (2), $T_{max}=5{\cdot}96$ newton-metres and it occurs at $s_{max}=0{\cdot}3432$, which corresponds to a speed of 657 r.p.m. The torque-slip curve calculated from equations (1) or (4) is shown in Fig. 2.

Approximate Circuit, Fig. 1(*b*).—From equation (6) $T'_{max}=3{\cdot}23$ newton-metres and this occurs at a slip given by equation (7) $s'_{max}=0{\cdot}2128$; this corresponds to a speed of 787 r.p.m. The torque-slip curve calculated from equation (5) or from equation (8) is also shown in Fig. 2.

Equivalent T-Circuit, Fig. 1(*a*).—Expressions for the torque-slip relation corresponding to Fig. 1(*a*) are not given here. However, the corresponding parameters have been deduced from the no-load and locked-rotor tests and a torque-slip curve calculated from them. This is also given in Fig. 2 and it lies within a few per cent of the curve calculated from the approximate circuit.

Test.—The stator of the motor was mounted in bearings and restrained by spring balances. The rotor was driven by a large-inertia d.c. motor whose speed could be adjusted as required. At a particular speed, the mains supply of 100V per phase was connected to the stator, and the torque it experienced was measured by spring balance. These torque values were corrected by adding to them the corresponding windage and friction torque values measured when the rotor was being driven and the stator left unexcited. In this way, the torque-slip curve over the range from rest to synchronous speed was obtained and this is also given in Fig. 2.

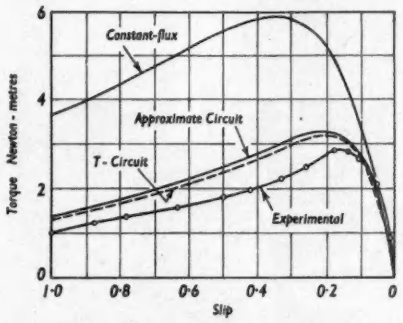

Fig. 2—Calculated and experimental torque-slip curves for a 400V, three-phase, 50 c/s, six-pole induction motor tested at 100V per phase

Comparison of Results

The torque-slip curve calculated from the constant-flux theory is some 150–250 per cent greater than that obtained by test except over the small region near synchronism. On the other hand, the corresponding curves from the approximate-circuit and the *T*-circuit lie only some 15–25 per cent above the experimental one for speeds below the breakdown point. Also for the latter pair of curves, the speed corresponding to maximum torque (787 r.p.m.) is very much nearer the experimental value of 810 r.p.m. than is that given by the constant-flux theory (657 r.p.m.).

However, the measure of agreement between experiment and approximate equivalent circuit theory is not as good as anticipated, and no attempt has been made to investigate the causes of this discrepancy. This might, for instance, have been done by using the more exact practical theory of D. Morris.[8] The results should therefore be taken as typical of those obtained by students using simple theories and a comparatively small induction motor.

Starting Time

Simple tests were made to check the validity of the starting-time equations (10) and (11). To obtain the moment of inertia of the rotor it was removed from the stator, and a bifilar torsional oscillation experiment carried out upon it ; this gave a value of $0{\cdot}0845 kg.m^2$ for J.

After reassembly, the rotor was left unloaded. The time of starting from rest to 900 r.p.m. with a 100V per phase supply was taken by means of a stop-watch. As a second check a " plugging " test was made. When the motor was unloaded and running near synchronism, the 100V supply was switched off and at the instant the speed fell to 900 r.p.m. the supply was again switched on in reverse sequence and the time was taken for the motor to reach 900 r.p.m. in the opposite direction ; this is the plugging time.

An electronic flashing stroboscope was used to fix the instants at which the rotor speed was exactly at 900 r.p.m. The means of the times of several such measurements were taken and they are given in Table I,

Table I—*Starting and Plugging Times*

	Starting.	Plugging.
	Rest to 900 r.p.m. $s=1$ to $s=0{\cdot}1$	900 r.p.m. backward to 900 r.p.m. forward. $s=1{\cdot}9$ to $s=0{\cdot}1$
	Sec	Sec
Constant flux, $T_{max}=5{\cdot}96$ *Nm*, Equation (10)	1·7	4·6
Approx. circuit, $T'_{max}=5{\cdot}96$ *Nm*, Equation (11)	6·4	13·9
Experiment	6·0	12·5

together with the times calculated from equations (10) and (11).

These figures show that the results from the approximate circuit equation (11) are extremely close to those measured experimentally. The times given by the constant-flux theory are far too optimistic and the errors are very large.

Conclusions

Sufficient has been given, theoretically and experimentally, to show that the constant-flux theory used in early studies of the induction motor is of very doubtful merit. The errors which it introduces are extremely large and lecturers who use it should be very careful to emphasise to students its very approximate nature.

In fact, results from the constant-flux theory are so very far from the truth that it is preferable to restrict studies at an undergraduate level to the approximate equivalent circuit of Fig. 1 (*b*), which has many merits : (i) it is easily deducible after the study of the transformer equivalent circuit ; (ii) results agree reasonably well with experimental ones ; (iii) mathematical analysis is fairly simple and ; (iv) it corresponds exactly to the circle diagram as usually taught to students at this stage ; thus, results from the circle diagram and from calculations are consistent with each other.

Acknowledgment

Thanks are expressed to Professor B. Hague for making available the facilities of the Electrical Engineering Laboratory of the University of Glasgow.

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[6] T. F. Wall, *Three-Phase Motors*, Newnes (London) ; first edition, 1951, pages 46–50.
[7] M. G. Say, *loc. cit.*, pages 185–194.
[8] D. Morris, " Some Tests on an Exact Practical Theory of the Induction Motor," *Proc. I.E.E.*, Part II, Vol. 97, December, 1950 pages 767–777.

Surface Plates.—Particulars have been received from Rubert and Co., Ltd., Chapel Street, Levenshulme, Manchester, 19, of a new range of surface plates that it is now making in eight sizes up to 18in square. These plates are made in close grained cast iron to conform to B.S. 817 in every respect, and they are ground and lapped to a high surface finish. If required, they can also be supplied ready grooved for use in precision lapping. The heavy ribbing on the underside of the plates is designed to form a central handle, by the use of which an operator can apply a balanced pressure on a plate when blueing or lapping work. Two side handles are provided for carrying purposes, and a three-point support is provided in the base by screws which can also be adjusted for levelling purposes when required.

Public Works Exhibition

No. I

THE products of nearly 300 firms will be displayed at the Public Works and Municipal Services Congress and Exhibition, which will be held in London at Olympia from Monday next, November 15th, till Saturday, November 20th. The exhibition will be opened by Mr. Nigel Birch, the Minister of Works, and will provide a comprehensive survey of the contractors' equipment of all kinds used by municipal and local government bodies in this country and overseas.

In the course of the congress, being held at the same time as the exhibition, some thirty papers will be presented for discussion dealing with widely different aspects of municipal organisation, including road materials, sewerage, traffic, housing, water supply, employee recruitment, and training, &c.

We have received from a number of the exhibitors preliminary details of the equipment they will have upon their stands, and descriptions of some of the newer plant are given in the notes which follow. From these descriptions an impression will be obtained of the wide scope of the exhibition and of some of the developments which have taken place in this country in the two years since the previous exhibition, and with which we have not previously dealt.

John Fowler and Co. (Leeds), Ltd.

A number of tractors and road rollers of different sizes is to be shown on the stand occupied jointly by John Fowler and Co. (Leeds), Ltd., and Marshall Sons and Co., Ltd., Gainsborough. A prototype model of a new wheeled tractor, shortly to be placed on the market by these firms, is illustrated in Fig. 1. This machine is designed for both agricultural and industrial use and is fitted with a Leyland six-cylinder, four-troke diesel engine developing 70 b.h.p. at 1100 .p.m. In first gear it has a drawbar pull of 6500 lb with a nominal speed of 2¼ miles an hour, and in its sixth gear a pull of 1500 lb at a nominal speed of 15¾ miles an hour. If weights are used on the rear wheels the drawbar pull in first gear can be increased to 7000 lb.

Ransomes and Rapier, Ltd.

A new tilting concrete mixer and the latest design of its ⅝ cubic yard shovel will be seen on the stand of Ransomes and Rapier, Ltd., of Ipswich. The "Rapier 424" ⅝ cubic yard shovel is supplied with interchangeable front end equipment for dragline, grab, dragshovel, skimmer and crane. In the latest design wider crawler tracks are fitted and the controls have been rearranged for easier operation. The machine is driven by a Perkins diesel engine through a fluid drive coupling transmission.

The new concrete mixer with its capacity of 5/3½ cubic feet is the smallest tilting drum mixer now made by the firm. It is a hand-loaded machine with mixing and discharging positions on both sides. One of the company's 4½ cubic yards capacity truck mixers will be exhibited fitted on a lorry and arranged for power take-off drive from the lorry gearbox. In this machine the spiral mixing blades are continuous from end to end of the drum, and are designed to give quick and complete discharge when drum rotation is reversed.

The five sizes of self-priming pumps to be shown will have capacities from 4000 to 48,000 gallons per hour. The other exhibits will include mobile cranes and fork-lift trucks.

International Harvester Company of Great Britain, Ltd.

A majority of the equipment shown this year by the International Harvester Company of Great Britain will have been made in the firm's works at Doncaster. A piece of new equipment of interest is the "Sterling" hydraulic 5-yard scraper, which is shown in operation in Fig. 2, and is designed for use with the International series 6 and 9 crawler tractors.

Fig. 2—5-cubic-yard hydraulically operated scraper

This scraper has a struck capacity of 3½ cubic yards and a heaped capacity of 5 cubic yards, and the maker states that hydraulic operation was selected for two reasons. One reason was that it was considered that cable-operated power control units tended to overload the 35–50 h.p. tractors; and the second was that positive hydraulic action improved the earth-moving performance of tractors within that range. The scraper has a mild steel plate bowl with a 6ft 10in by 1ft 10in floor, and its tail gate is 3ft 3in high. A three-piece reversible blade is fitted, which has a 3ft centre section with a 1ft 6in section at each end, to give a total width of 6ft. The blade is designed for a 9in depth of cut and a 1ft 3in depth of spread.

Hydraulic power for the jacks used for operating the bowl lift, tail gate and apron is supplied through flexible pipes from the tractor used to haul the scraper. Two control levers are operated by the tractor driver. One lever is operated to raise and lower the bowl through the medium of two hydraulic cylinders. The second lever raises and lowers the apron, and after the apron is fully raised it operates the forward movement of the ejector plate under the full control of the driver to give quick dumping or fine grading as required.

The scraper weighs about 6000 lb empty or 19,000 lb full, 45 per cent of the load being taken on the front axle and 55 per cent on the rear axle.

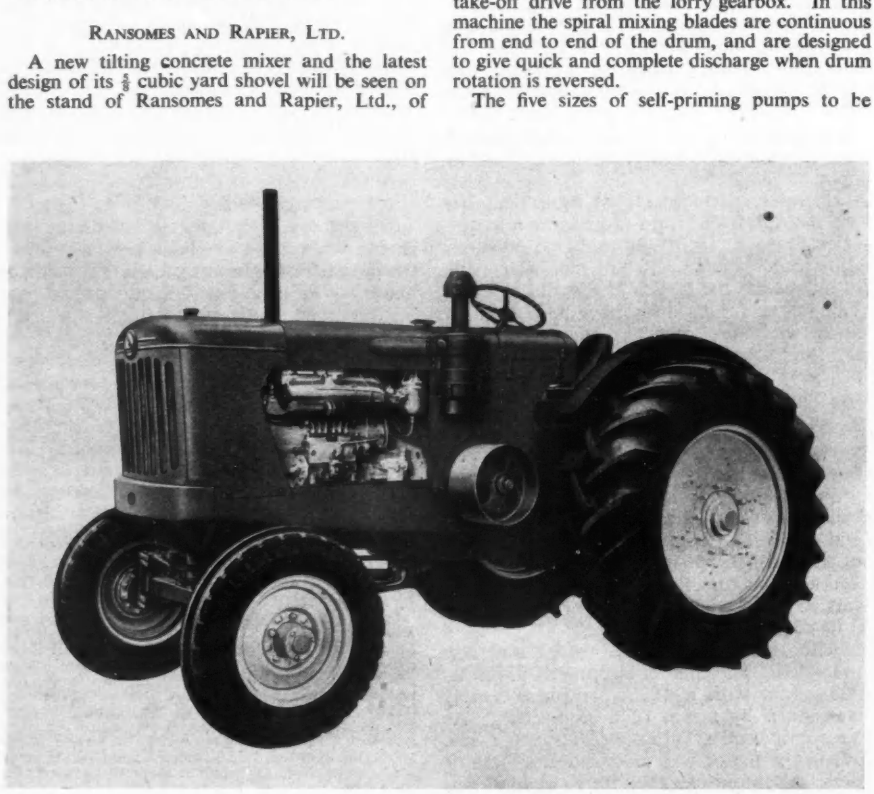


Fig. 1—70 b.h.p. diesel tractor with a drawbar pull of 6500 lb in first gear

Winget, Ltd.

The "Poclain" lorry-mounted excavator made by Winget, Ltd., Rochester, is illustrated in Fig. 3. This machine has all its movements operated hydraulically, power being supplied by a 16 h.p. diesel engine coupled to a high-pressure hydraulic pump. A range of alternative front-end equipments can be quickly fitted. When the ½ cubic yard face shovel is used the machine will dig down to 5ft 6in below ground level and discharge up to 13ft above the surface. Either ½ or ¾ cubic yard skimming buckets can be fitted for loading up to 10ft 6in above ground level. For digging vertical walled trenches to a depth of 9ft a trench hoe can be fitted, and the same equipment is used to cut a curved section ditch up to 13ft wide by 9ft deep or a pipe trench 3ft 6in

Fig. 3—Lorry-mounted hydraulically-operated excavator

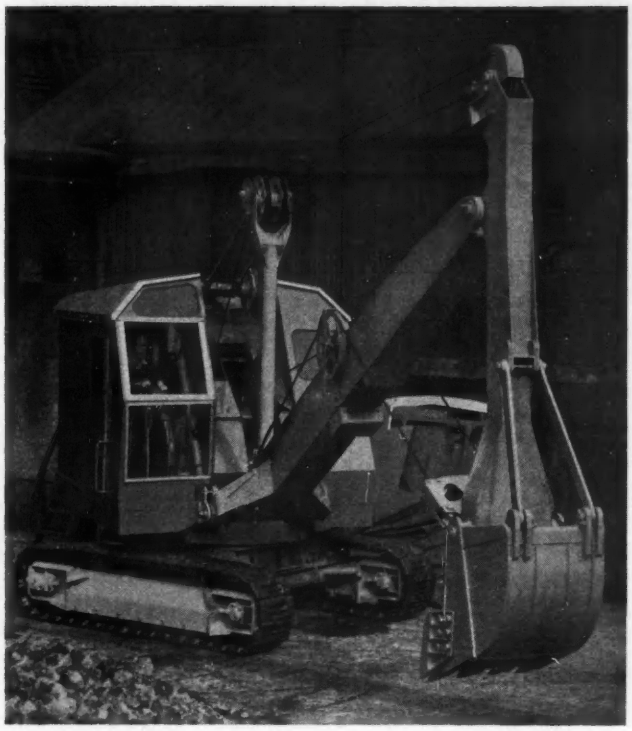


Fig. 4—0·625-cubic-yard excavator equipped as a drag shovel

wide and 7ft 6in deep close to the side of roads or walls.

Another new machine on this firm's stand will be the Winget-Parsons "Trenchmobile," which has been developed to meet the need for a reasonably small machine for cutting trenches and be capable of moving from site to site under its own power. This machine will cut trenches from 8in to 16in wide in 1in increments to a depth of 5ft. Cutting speeds are infinitely variable in three ranges forward and reverse, the low range being up to 6ft per minute, the intermediate range to 11ft per minute, and the high range to 14ft per minute. The box-section boom is telescopic for initial depth setting, the boom hoist being hydraulically operated with positive down crowd. On the road, the machine can travel at speeds up to 12 m.p.h. Its 42 h.p. diesel engine gives ample power for digging or travelling, whilst the five forward and one reverse gears allow good flexibility either on or off the site.

This firm's recently introduced "Skip-Lift" portable high discharger is designed to eliminate the need for a raised discharge mixer within the limits of 14/10 cubic feet, and it can be used with any of the company's tilting or non-tilting mixers up to this capacity.

It consists of a truck-mounted runway on the rails of which a steel skip is hoisted or lowered through a 5 h.p. engine. The skip hoisting is effected through a double wire rope operating over large machined sheaves and pulling on a cross beam provided with flanged rollers engaging in the runway, and a pair of struts pivoted on pins on the skip cradle. The discharging height of the skip is 7ft 6in and all or part of its load can be discharged under complete control through the operation of a single lever.

Priestman Brothers, Ltd.

The "Tiger V" excavator to be shown by Priestman Brothers, Ltd., Hull, for the first time is illustrated in Fig. 4. This machine is driven by a 57 b.h.p. diesel engine and is crawler mounted on 18in or 24in tracks. It has a $\frac{5}{8}$ cubic yard bucket capacity, and can be arranged as a crowd shovel, drag shovel, skimmer, dragline, grab, crane or pile driver.

The machine will be exhibited as a drag shovel with a standard $\frac{5}{8}$ cubic yard doorless bucket, with a cast steel lip and socketed teeth and a cutting width of 36in. An alternative bucket is available giving a 30in cutting width and, with either of these two equipments, a working depth of 17ft is possible.

The redesigned undercarriage frame of the machine is of a deep section folded construction giving strength and rigidity without dirt-gathering ledges and projections. A new, simplified system of track adjustment employs a screw jack and packers of varying thicknesses, and eliminates the use of fixed adjusting screws. A strongly constructed steel cab, the upper corners of which are chamfered to clear universal railway loading gauges, covers the driving compartment and all machinery.

Blaw Knox, Ltd.

The "BK–Fifty" $\frac{1}{2}$ cubic yard capacity excavator shown with the contractors' plant on the stand of Blaw Knox, Ltd., 94, Brompton Road, London, S.W.3, incorporates many new modifications which have been introduced to improve performance, reduce and simplify mechanical maintenance and facilitate operation. The machine is now driven by a Perkins "L 4" four-cylinder diesel engine developing 50 h.p. at 1450 r.p.m., and having a maximum torque of 165ft-lb at 1000 r.p.m. The machine exhibited (Fig. 5) will be fitted with a face shovel attachment which is interchangeable with a drag shovel, skimmer, dragline, grab, crane or pile-driving equipment.

When arranged as a face shovel a 15ft 9in welded steel boom is used with a 12ft 6in dipper stick, giving a discharge height of 20ft 9in. A fully racked twin tubular dipper stick works in conjunction with rope-driven pinions giving powerful and accurate crowding. The bucket

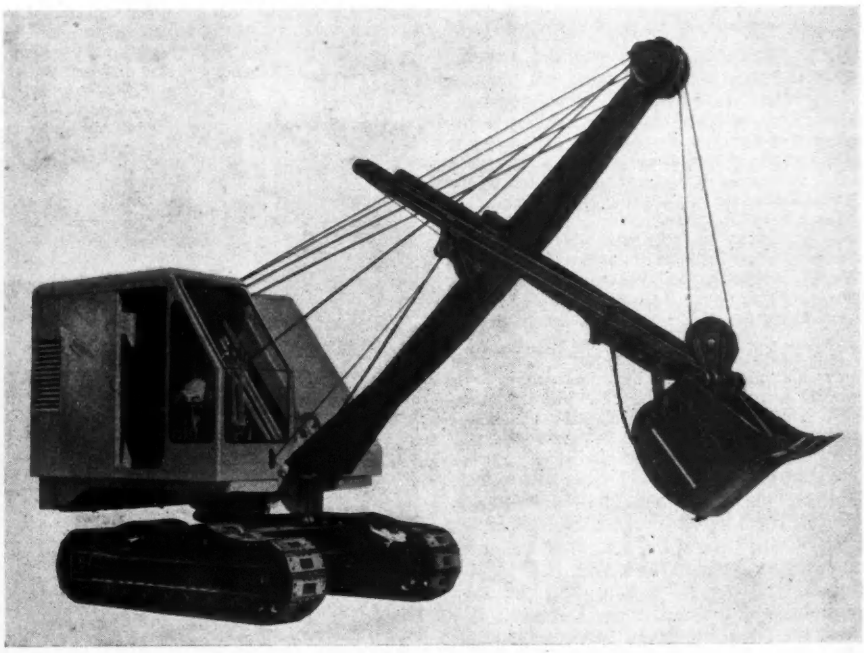


Fig. 5—Half-cubic-yard excavator with face shovel attachment

door latch is tripped by an electric motor controlled by a push button on the head of the driver's swing lever. With the drag shovel equipment an 8ft arm is fitted and a standard ½ cubic yard bucket, used with its side cutters, has a cutting width of 31in. A differential drum is mounted on the main boom in this case to give a step-up ratio of 2·1 to 1 for the bucket line pull which is transmitted directly by two ropes to the bucket bridle. This obviates need for a padlock sheave on the bucket and keeps it clear of obstruction at all digging angles. Drag shovel working can be carried out with this equipment from 13ft 6in above to 15ft 9in below ground level.

A light-weight ½ cubic yard skimmer bucket can be used on a 17ft 10in boom on the machine. This welded box-section boom has wide, deep ways along which the bucket runs on hardened steel rollers, to give a 10ft long forward digging movement. In this case again a push-button controlled electric trip is used to release the catch on the bucket door. For dragline working with a ½ cubic yard bucket the standard 30ft boom of lattice design used can be fitted with 5ft and 10ft extensions to give a maximum length of 40ft. The same boom is used when adapting the machine for crane operations or as a pile-driver.

A new "Super-12" heavy duty motor grader exhibited is fitted with an engine developing 118 b.h.p. and has power-operated controls, a six-speed gearbox, fully revolving blade, a 90 deg. bank cutting angle, and a wide vision cab.

Atlas Diesel Company, Ltd.

A recent addition to the portable air compressors made by the Atlas Diesel Company, Ltd., Wembley, Middlesex, is the machine illustrated in Fig. 6, which has a free air delivery

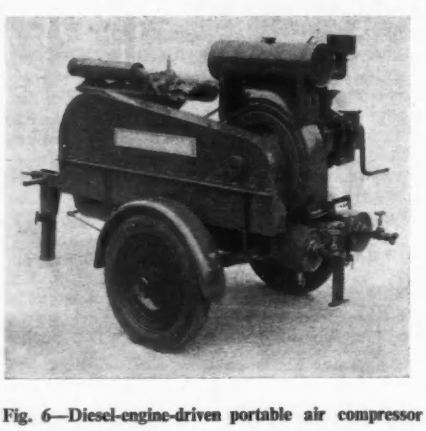


Fig. 6—Diesel-engine-driven portable air compressor

of 37 cubic feet per minute at 80 lb per square inch. It consists of one of the firm's standard two-cylinder, vee, single-stage, air-cooled compressors driven by an Armstrong Siddeley single-cylinder, air-cooled, four-stroke diesel engine developing 11·6 h.p. at 1610 r.p.m. The engine pulley is coupled by a centrifugal clutch to the flywheel to enable easy starting of the engine.

The engine and compressor are mounted on two cylindrical air receivers which form the chassis, carried through a single axle and semi-elliptic springing on pneumatic-tyred road wheels. Towing and braking equipment is fitted to permit the machine to be hauled at speeds up to 20 m.p.h. on roads.

This company is also showing a number of other air compressors, including one of its recently introduced "One-ten" portable compressors fitted on a four-wheeled chassis. These machines are driven by the Fordson industrial diesel engine and have free air delivery of 110 cubic feet per minute at 100 lb per square inch. Other exhibits on the stand will include a loader, rock drills, air hoists and paint-spraying equipment.

Rotary Hoes, Ltd.

The ancillary plant designed for use with the "Platypus" crawler tractors of Rotary Hoes, Ltd., East Horndon, Essex, will include a "Bulloader" loading equipment. This loader has a bucket with a struck capacity of 20 cubic feet or a heaped capacity of 1 cubic yard. It is operated by double-acting hydraulic rams, which carry the bucket over from the loading position at the front of the machine to discharge it over the rear. The equipment is designed to dig to a depth of 9in below ground level and discharge at a height of 7ft 6in.

Aveling-Barford, Ltd.

One of the dumpers to be shown for the first time by Aveling-Barford, Ltd., Grantham, is the 7½ cubic yards capacity machine to be seen in operation in Fig. 7. It takes a payload of 20,000 lb and when fully loaded weighs 40,320 lb. The six-cylinder Leyland diesel engine of the

Fig. 7—Heavy duty diesel-engine-driven dumper of 7½ cubic yards capacity

dumper develops 150 b.h.p. at 2200 r.p.m. and it drives through a four-speed gearbox in both directions of travel with a top speed of 21·8 m.p.h. Two-way steering enables the driver of the machine to face the direction of travel and retain the normal steering action when reversing.

The body and frame are of heavy welded steel construction and tipping is effected by twin hydraulic two-stage telescoping rams which give power return of the body at the conclusion of tipping. A maximum tipping angle of 70 deg. is attained in about sixteen seconds and the body can be held at any position within this limit.

One of the road rollers shown by this firm will be a new machine which is built in two sizes with working weights (unballasted) of 2¼ tons and 3¼ tons. It is powered by a two-cylinder vertical, water-cooled diesel engine which, driving through a constant mesh gearbox gives the machine two speeds—2 and 4·12 m.p.h.—in both forward and reverse directions. The final drive is by worm and wheel, the unit incorporating differential gear which can be locked from the driving seat.

Galion (Great Britain), Ltd.

A new motor grader is now being made in this country by Galion (Great Britain), Ltd., Thornes Moor Road, Wakefield, for lighter classes of earth-moving work where use of the firm's 100 h.p. machine would not be justified on economic grounds. This new machine, "Model 603," is powered by a four-cylinder diesel engine developing 50 h.p. at 1450 r.p.m.

The general design of the grader (Fig. 8) follows that of other "Galion" machines and all its blade operations are hydraulically controlled. Manual steering is provided through the front wheels, which are fitted with tyres of the same size as the four rear wheels. A chain-driven tandem drive is employed on all four rear wheels and the four forward speeds provided range from just over 2 m.p.h. in first gear to 18 m.p.h. in top gear. The speeds are variable through the governor control, and they have been selected to enable the machine to operate efficiently under most conditions. The standard mould board is 10ft wide by 16⅜in high, its lift above ground being 12in, and the maximum side reach of the blade is 45in outside the front wheels. The blade may be turned through 126 deg. and a wide range of blade adjustments is possible.

Frederick Parker, Ltd.

The largest machine displayed on the stand of Frederick Parker, Ltd., Leicester, will be a mobile "Starmix No. 8" asphalt and bituminous mixing plant, with a capacity of 12–25 tons per hour. Also exhibited will be the small mobile "Spot-Mix" asphalt and bituminous mixing plant, which, with its capacity of 5–10 tons per hour, has been specially designed for road-patching, laying car parks, playgrounds, tennis courts and similar jobs.

(To be continued)

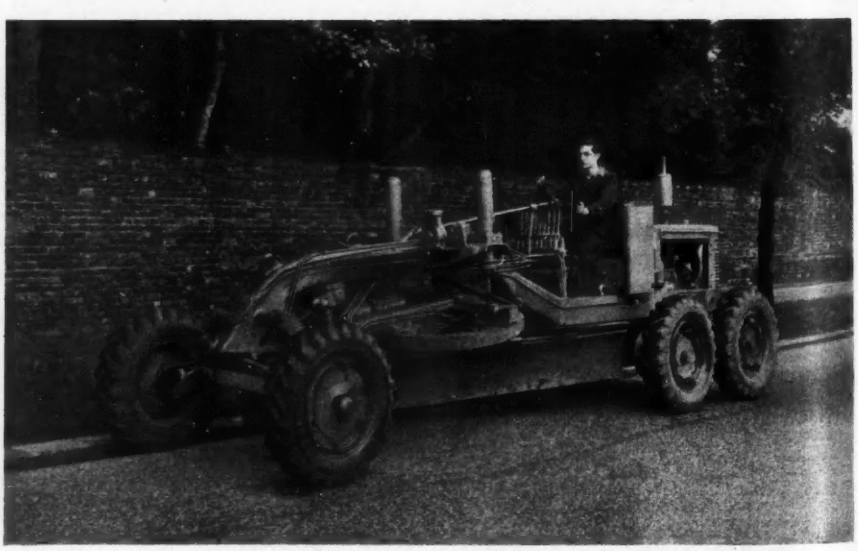


Fig. 8—50 h.p. motor grader

Fuel Economy in Materials Handling

By R. SOLT, B.Sc., A.M.I.E.E., A.M.I.Mech.E.*

This article is confined to the handling of materials in the iron and steel industry; it surveys the common practices and gives some comparative data on the use of fuel in transport and handling systems. The scale of the problems involved is illustrated by reference to the amount of handling which takes place in steel works. Once the plant has been laid down, fuel economies must be achieved by good maintenance and by efficient operation and control of the existing facilities. In the case of a new works, the design of its layout and choice of equipment will determine the efficiency of the plant when it comes into operation. The service given by a transport or handling system may affect the fuel efficiency of the process it serves; this effect is shown to be important.

THE problems of handling materials may be related to fuel economy in several ways. The present article deals with the fuel consumption of the handling equipment itself.

Any attempt to discuss this subject is made doubly difficult because there is at present no valid basis for comparing the fuel consumed in transport and handling at different works. Moreover, every transport system is essentially a service, and its efficiency cannot be measured without reference to the process it serves. This is also true in the field of fuel economy, where the efficiency of the transport and handling equipment and its organisation may affect the fuel consumption of the manufacturing processes themselves. This is the case, for instance, where a product is transported hot from one process to another: the longer the transit time, the more heat is lost and will have to be replaced later. Or, again, the fuel consumption of a hot process will usually rise if the process time must be extended, because the supply of raw materials is delayed by an inefficient transport system.

Although these effects are here only mentioned in passing, they are important and have been studied on their own account. This article, however, surveys some of the practices and gives such comparative data as are available on the use of fuel in transport and handling systems in the iron and steel industry.

The importance of the subject can be gauged by the scale of the operations involved. The amount of handling incurred in the manufacture of finished steel is indicated in Fig. 1, a diagrammatic flow sheet of a hypothetical (but fairly typical) integrated plant.

The figures in brackets are based on national averages, and represent the tons of material which must be handled from stage to stage of the process, for every 1000 tons of ingots made.

Adding these figures, one finds that a total of over 10,000 tons of material has to be moved in the course of making 1000 tons of ingot steel, or 800 tons of finished product; in other words, nearly thirteen times the weight of the finished product must be moved in the course of its manufacture. This does not include the handling of raw materials into stock, nor any handling which would be involved if the works make their own coke or sinter, or prepare their coal and ore. Additional processes at the finishing end may include cold rolling, pickling, or heat-treatment, all of which would call for still further handling.

This large amount of transport and handling obviously requires substantial equipment, and uses much fuel and power. Relative to other manufacturing costs, however, the transport fuel and power costs in a works are always small. The question of fuel economy in this connection is therefore more important from the point of view of fuel saving on a national scale than it is to the individual works on the score of money savings. How much fuel could be saved without impairing the efficiency of transport and handling services can only be estimated; the Ridley report on national policy for the use of fuel and power, puts forward a figure of 15 to 20 per cent of the present consumption as a possible saving on solid fuel used for transport in industry at large. From the point of view of an individual works, transport costs may represent only about 5 per cent of the total conversion costs, and fuel costs amount to only a part of the transport costs (for instance, coal and water make up about 25 per cent of the total cost of keeping a steam locomotive running). The savings which can be made are therefore relatively small. Fortunately, though, the fuel efficiency of a system is usually closely related to its general operating efficiency; fuel savings should therefore often follow if a transport and handling system is made more efficient for the sake of better productivity.

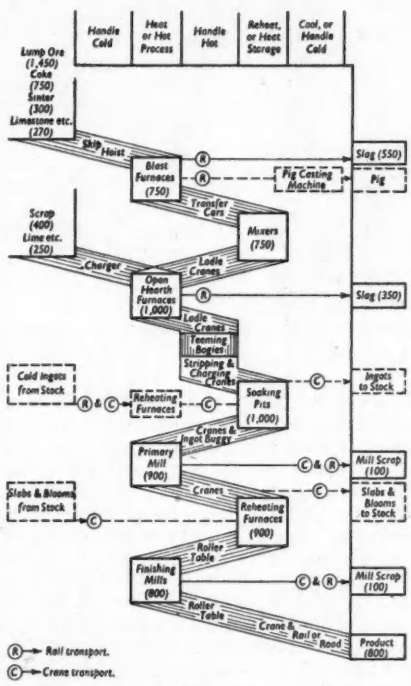


Fig. 1

Maintenance

Once a plant has been laid down and all handling and transport equipment provided, it is not usually easy to make sweeping fuel economies. The pattern of materials handling about the works will be largely dictated by the plant layout, and by the transport facilities available, so that savings can be brought about only by attention to the details of the manner in which the equipment is used.

At its simplest this means attention to the maintenance and upkeep of the available equipment. A striking example of the effect of good maintenance (or of its absence) is given by the following figures for starting resistances of railway wagons, in pounds per ton load :—

TABLE I—*Starting Resistances of Bearings on Rolling Stock*

Bearing	Approximate starting resistance, lb/ton
Plain bearings:	
Well lubricated	20
Poorly lubricated	40
Damaged by misuse*	75
Roller bearings:	
Well maintained	10

* E.g., ingot car bearings which repeatedly have hot metal spilt over them, or where ingot cars are used as stripping blocks.

Transport Operation and Control

Attention to the manner in which the equipment is used must also include attention to its control. Efficient control may, for instance, enable a given number of locomotives to do more work; conversely, it may be possible to deal with the same amount of work with a smaller number of locomotives, if control is improved.

For example, the report of the Anglo-American productivity team on iron and steel tells of a modern American works which handled some 560,000 tons of material per month with only nine working locomotives; a plant of about half that size in this country would employ some eighteen locomotives to carry out the work. Part of this difference can be accounted for by the fact that the larger works would have heavier locomotives (so that a greater load can be transported on each trip), and that the railway system in the modern plant would be relieved of much work by alternative means of transport (conveyors and road vehicles); some of the difference, however, must be attributed to more rigid organisation and closer control.

In the last few years, several major British works have introduced radio control of their locomotives. Opinions on its usefulness differ; but wherever the equipment has been in use for some time there seems to be a fairly general feeling that it could not be removed without being missed. No British works has yet gone to the length of one American plant at which the traffic controller operates from a mobile radio van, so that he is free to move about the site.

Assessing Transport Efficiency

One cannot assess the efficiency of a transport system without a valid standard by which it may be measured. The task is doubly difficult because transport is primarily a service, and its efficiency must therefore be measured (at least in part) by its effect on the processes it serves. Whilst one would hardly expect to find a locomotive, or a crane, working at much more than 75 per cent utilisation (i.e. an average of forty-five minutes in every hour), it is not necessarily true to say that a unit with such high utilisation is doing its work efficiently; neither could one condemn a unit which works only 60 per cent of its time or less as being inefficient. The aim must surely be to provide transport when it is needed, and one measure of the efficiency (or inefficiency) of a transport system must be the delays which it imposes

* Operational Research Section, British Iron and Steel Research Association.

on the processes it serves. This must have been in the mind of the managers at one modern British plant, when they caused a continuous record to be kept of the changes of position of all locomotives and ingot bogies between their melting shop and stripping bay. Recording is done in a similar manner to the route analysis of Fig. 2; the record shows up delays and their causes, and by locating the reason helps to avoid recurrence.

Plant Layout

Whilst close control of a materials handling system of this kind may be necessary to render it efficient, no amount of organisation can compensate for a bad layout, or for the wrong kind of equipment. In the design of the new Abbey Steel Works, the question of layout and equipment of the melting shop and scrap bay were thought sufficiently important to justify the building of a working model. Different kinds of charging systems were tried out in miniature to ensure that the best arrangement should be selected. By contrast, a length of track was recently laid down in a medium-sized works to provide much-needed additional storage space for wagons; but access to this siding is so awkward that it is hardly ever used. Examples of this kind occur if there is insufficient planning of an operation: it is essential always to relate at the outset what it is that needs to be done, with the manner of doing it, and the means by which it shall be done. Organisation, layout and equipment must be designed together in detail.

There is one feature of this integrated planning which may sometimes be neglected. Most steel-making processes use a number of different materials which have to be brought from different parts of the works, and it is often difficult to bring them together without allowing the flow lines to cross or to overlap. It may, however, be possible to use the fact that some processes are carried out at different levels from others, and flow lines can be made to cross at different levels to avoid obstruction and mutual interference. There is considerable scope for such three-dimensional planning in designing an open-hearth melting shop, where both the furnace stage and the valve house can provide access to the furnaces. For instance, interference with the charging system on the stage can be greatly reduced if there is provision for bringing bricks to any furnace under repair at valve house level, and then raising them by brick elevator on the pit side.

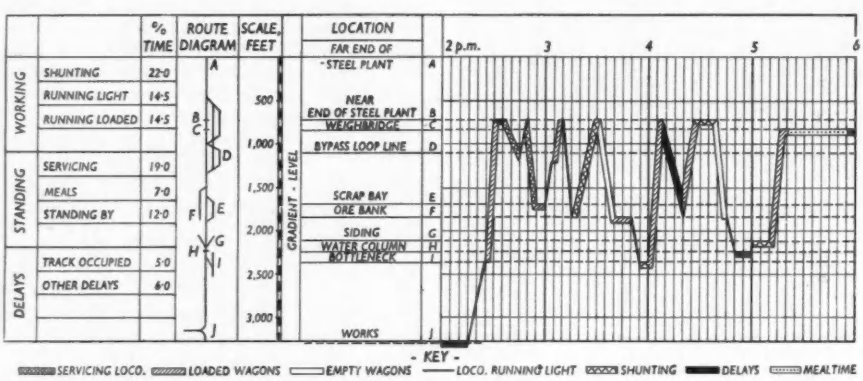


Fig. 2

Alternative Means of Transport

The selection of alternative methods of transport and handling must be made also in the light of their operating efficiency. Traditionally, rail transport—with steam locomotives—is the most widely used in steel works. For some years, diesel locomotives have been gaining in popularity in British works, and they are now coming into general use. Whether the replacement of steam locomotives by diesels can be economically justified in an existing works depends partly on the layout; for instance, the greater overload capacity of the steam locomotive enables it to cope better with steep gradients. Compared with the frequent servicing periods needed by a steam locomotive, the diesel locomotive has the advantage of being almost continuously available; unless this fact can be put to good use, however, it will not give rise to any economic advantage.

There is no doubt that the thermal efficiency of diesel locomotives is greater than that of steam locomotives on this kind of work: British Railways estimate that their diesel shunting locomotives make eight times better use of the heat content of their fuel than steam locomotives on the same duty; the Railway Executive has recently made provision for a further 500 diesel locomotives for its shunting yards. In a steel works where diesel locomotives can be used to good advantage, their hourly running cost of about £1 2s. 6d. (including maintenance) compares very favourably with that of £1 12s. 6d. for steam locomotives.

The transport of raw materials to the blast-furnace bunkers is now frequently designed to be handled by conveyor. The following table of comparative costs of rail and conveyor transport has been compiled from figures which were obtained from a small iron works supplied by rail on the one hand, and from a somewhat larger conveyor installation on the other. The cost per hour of the rail system has been taken as 100 per cent:

TABLE II—*Relative Costs of Railway and Conveyor Transport*

	Locomotive	Conveyor
Traffic handled (tons/hour)	15–40	90
Cost per hour:		
Wages	55%	30%
Fuel or power	25%	5%
Maintenance	20%	30%
Totals	100%	65%

Figures are taken from *Locomotives in Iron and Steel Works*, by E. L. Diamond. Neither track nor conveyor structure maintenance costs are included.

Another alternative means of transport which is coming into more general use is road transport, internally, as well as for delivery of materials and product both to and from the works. On the basis of thermal efficiency this doubtlessly represents a saving; the fuel consumption (in B.Th.U. per mile per ton capacity) of a slow freight train is almost five times as great as that of a 14-ton diesel lorry. Road transport has the added advantage of considerably greater flexibility. One works, with an already congested railway system, is arranging for billets to be taken to the finishing mill on trailers; these are drawn by a limited number of traction units. One may estimate that it becomes economical to run up to three diesel tractor units, if one can thereby replace one locomotive.

Effect on Processes Served

The preceding examples are related to the fuel consumption of transport and handling equipment itself. It has been pointed out that the efficiency of handling materials from one process to another may itself have a considerable effect on the fuel efficiency of the process.

The movement of ingots from the casting bay to the soaking pits is an example of handling hot materials, where lost time during transport means a loss of heat. The newly teemed ingot must be allowed to solidify sufficiently before it can be stripped of its mould; it should then be charged to the soaking pit as quickly as possible. In round figures, the heat content of an ingot as teemed is 13 therms per ton, and as supplied to the mill after soaking is 8 therms per ton. Despite this initial surplus of heat, the fuel requirements of soaking pits (found during an extensive recent survey) average some 17 therms per ton of ingot. Much of this heat requirement could be saved by efficient transport and handling.

The charging of open-hearth furnaces presents an example of a different kind: inability to supply materials to any furnace whenever and as soon as it is ready to accept them, leads to delay and increases the cycle time of the furnace. The output of the furnace suffers as a result, and so does the fuel consumption per ton produced. Nevertheless, of several open-hearth melting shops which were recently visited, only one genuinely claimed to be free from delays on the score of inadequate charging facilities. All the others suffered from charging delays, some seriously so.

Further discussion of such problems is beyond the scope of this article. They are, however, problems which are being actively tackled by the more modern works in the industry. Their solution presents extreme difficulties in old works, many of which are producing much higher tonnages than were ever envisaged when the works were originally planned. Under these circumstances, continuous care is essential to avoid excessive waste of fuel. It is only in the new and larger works where full use can be made of modern equipment that concentrated attention to methods and organisation will ensure truly efficient use of fuel.

Development Plans for the Central African Federation

EXTENSIVE development plans for the Central African Federation have been recently announced. Total expenditure is estimated at £70,250,000, of which more than £24,000,000 will be spent in the coming financial year. The plans cover the next three years and do not include development by the individual territorial governments during that period. Major items include the development of the new Salisbury airport, communications and transport. Lake Nyasa is to be developed as the main line of communication from the end of the railway line northwards. Agriculture and social services are to receive special attention. The United States is to lend the Federation about £3,500,000 for the purchase of locomotives, rolling stock and permanent way material and supplies.

Plastic Dry Bearing

A NEW form of dry bearing which has been introduced by the Glacier Metal Company, Ltd., of Alperton, Middx, is designed to take full advantage of the particular properties of the plastic polytetrafluorethylene (P.T.F.E.). This bearing is suitable for a wide range of application on all forms of equipment where the use of lubricants is undesirable or the provision of adequate lubrication difficult. Initially the firm is supplying the bearings in thirty-eight standard bush sizes with nominal bores from ⅜in to 2in, and in the form of thrust washers in eighteen sizes with bores from ½in to 2¼in.

The new bearings consist essentially of a steel backing lined with porous bronze impregnated to its full depth with P.T.F.E. and having a layer of the plastic about 0·0001in thick upon its surface. In the process of manufacture composite strips of the bearing material are pressed into butt-jointed wrapped bushes similar to the firm's well-known standard design of wrapped bushes.

P.T.F.E. is extremely inert and has a dry surface coefficient of friction in the region of 0·05; this low friction is a surface property of the material and it does not depend upon the formation of a low shear strength film as with solid lubricants. This means that under ideal conditions no measurable wear should take place as a result of friction on a P.T.F.E. surface, and any wear which does occur is due to the roughness of the mating surface. It is recommended that the shafts used with these bearings should have virtually no running clearance, and that they should have a good ground finish, preferably not coarser than 10 micro inches.

When fitting the bearings special precautions have to be taken to avoid damaging their surfaces and the bores must not be machined after the bushes are fitted in their bore, otherwise the P.T.F.E. film will be destroyed. The plastic is stable up to a temperature of 327 deg. Cent. and where used in bearings an ambient temperature of about 280 deg. Cent. is permissible.

If used in block form for a bearing P.T.F.E. has many disadvantages, but by incorporating it in a strong metal matrix it is given the strength, heat conductivity, temperature and size stability of the metal; whilst the frictional, chemical and wear-resisting properties of the plastic are fully retained. Many shaft materials have been tried with the bearings by the makers who state that soft and hardened steel, hard anodised aluminium, cast iron, &c., can be used to advantage, but very soft materials and alloys high in copper are not generally suitable for use with them.

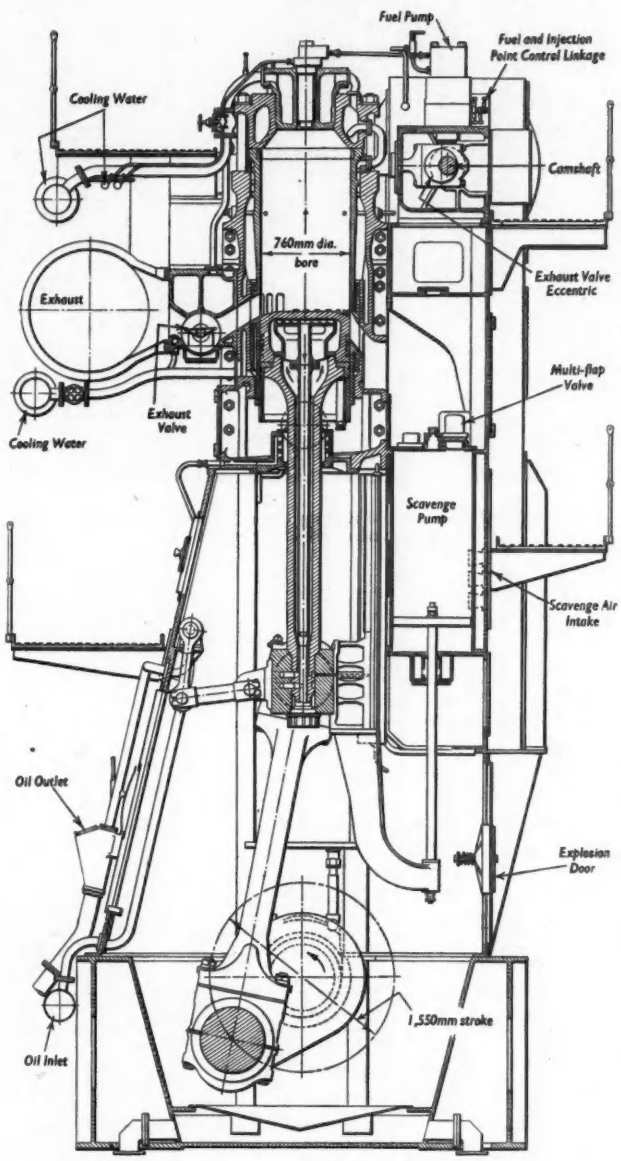
In a normal bearing the oil serves to distribute the frictional heat generated and so facilitates its rapid removal from the bearing surfaces. In a dry bearing no liquid is present to serve this purpose, and so the load and speed capacity of the bearing are determined largely by the ability of the assembly to dissipate heat. For these dry bearings, therefore, a P.V. factor, i.e. the load in pounds per square inch of the projected area multiplied by the surface velocity in feet per minute, may be quoted. The makers point out, however, that in using these P.V. factors, it should be borne in mind that the precise details of the assembly will affect the satisfactory operations of the bearings, and for this reason the interesting performance figures quoted by the makers are for general guidance only. For example, it is stated that with a rotating shaft in a fixed bush and the load fixed relative to the bush a minimum life of 1000 hours is possible with a P.V. factor of 3000, and this life is increased to 10,000 hours with a P.V. factor of 1800. In the case of a fixed shaft and a rotating bush, with the load rotating relative to the bush, there is a minimum life of 1000 hours with a P.V. factor of 12,000, and this life is increased to 10,000 hours with a P.V. of 7500. It has been found that a lead deposit or the chrome plating of a shaft considerably increases the P.V. value, and although the bearings are designed primarily for use without lubricants, the presence of a liquid is in most cases particularly advantageous.

OIL RESEARCH COMPANY.—We are informed that a new company, "Shell" Research, Ltd., is being incorporated to take over the research assets and activities in the United Kingdom of the Royal Dutch/Shell group of oil companies, which were handled formerly by the Shell Petroleum Company, Ltd.

Diesel Engine for Direct Drive

SOME years ago, in order to fulfil the demand for larger marine units suitable for boiler fuel oil, Sulzer Bros., Ltd., of Winterthur, Switzerland, began the development of the "RS" series of two-stroke engines. In a previous article (THE ENGINEER, July 25, 1952, page 120) we described the "RS 58" engine, which has a bore of 580mm and a stroke of 760mm. It is rated at 520 b.h.p. per cylinder at 240 r.p.m., and built in units of from four to twelve cylinders mainly for geared multi-engine propulsion. One of the advantages of this kind of drive is the lower overall height of the smaller engines, compared with that of a single larger one. This is particularly felt in passenger liners, where it permits additional decks to be carried above the engine-room. When such considerations do not hold, as for cargo ships or tankers, the simplicity of the direct drive may be preferred, and it is for this application that the "RS 76" engine has been evolved.

The "RS 76" is a larger version of the "RS 58," with a bore of 760mm and a stroke of 1550mm. Nominal rating per cylinder is 1000 b.h.p. at 115 r.p.m. The design considerations of the "RS" series have been discussed elsewhere.* Up to the present eight units with a total of fifty-nine cylinders have been built by Sulzer licensees. Our illustrations and the performance curves show the first engine of this class to be built at Winterthur, which we saw on the test bed recently.



Sectional elevation of "RS 76" diesel engine of 760mm bore by 1550mm stroke

The engine, which is to be installed in the 10,500 gross register ton cargo vessel "Wonsonobo," of the Royal Rotterdam Lloyd, is a direct reversible two-stroke unit of the crosshead pattern. The ten single-acting cylinders have a combined nominal output of 10,000 b.h.p., giving a weight/power ratio of 62 kg per metric h.p., or 138 lb per British h.p.

Welded construction is used up to the cylinder blocks, since many licensees have experience of welded structures, but find it difficult to obtain large castings. Shipping companies also tend to favour the welded design.

The use of a crosshead enables the cylinders to be separated from the crankcase by a stuffing-box around the piston-rod. This prevents contamination of the crankcase lubricating oil with the fuel and is particularly important when running on heavy fuel oil. At the same time, the presence of air under the piston in place of an inflammable air/oil mixture eliminates the danger of crankcase explosions due to a hot piston. Nevertheless, in order to give protection from the effects of explosions, which might be caused in some other way, explosion doors are fitted along the port side of the engine; these are spring loaded so that should an explosion occur ingress of air and consequent secondary explosions and fire would be prevented.

The welded A-frames are strengthened each by pre-tensioned tie bars. Bearing caps of the white-metalled crankshaft bearings are held in place by screwed jack struts between the cross members of the frames and the caps.

The crankshaft is of composite construction with webs and crankpins made from one piece being shrunk on to the main journal.

A single-slider crosshead is used which carries underneath it an arm to which the piston-rod of the scavenge pump is attached. Lubricating oil to the crosshead and crankpin, and cooling oil to the piston, are supplied through a linkage connected to the crosshead. The nut on the piston-rod is turned by applying a hydraulic spanner, for which pressure oil is supplied by a hand pump located at the end of the engine, with tap-offs

* W. Kilchenmann, *Trans. Inst. Marine Engineers*, June, 1953, page 137.

at each cylinder. The scavenge pumps are double acting and are equipped with multi-flap valves ; they discharge into a common manifold so that pressure fluctuations are minimised. Easy access to valves and ports for servicing has been provided.

In order to avoid the need for excessive headroom for dismantling, the length of the piston was kept short. In consequence the piston does not, during most of its stroke, separate the scavenge air and the exhaust, and a special exhaust valve had to be provided to achieve this.

It is an oscillating valve operated from an eccentric on the camshaft. Since complete airtightness is not required, the valve is given a generous clearance so that thermal distortion in the 340 deg. Cent. exhaust does not cause jamming. The sharp edges of the valve serve to scrape away any deposit which may be formed, while a spring-loaded member of the linkage prevents damage should a broken piston ring become lodged in the valve.

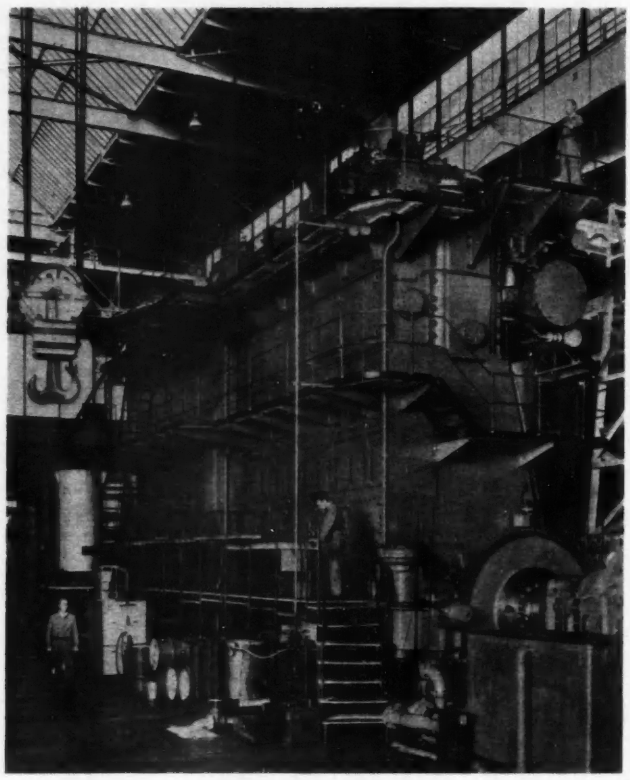
During the upward stroke the exhaust is closed by the valve even before the piston covers the scavenge ports, although these are actually lower than the exhaust ports. The result is after-charging, the cylinder being filled with air up to the full scavenging pressure without the provision of a second, higher row of scavenge ports fitted with non-return valves.

The method of cross-flow scavenging here employed has the advantage over uniflow scavenging that no valve ports in the cylinder head are required, thus giving a stronger design, and that the mechanically complicated valve gear is dispensed with.

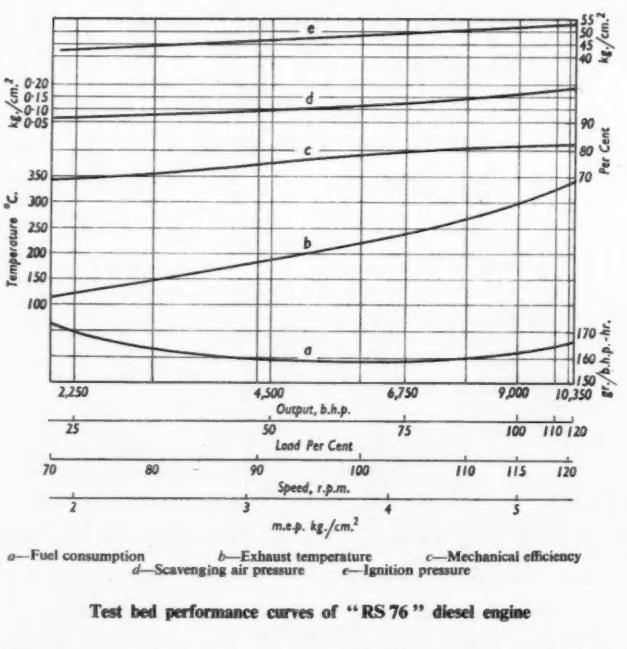
With heavy fuel oil, pipelines must be kept as short as possible so as to avoid undue pressure in the fuel pumps. The injection pumps are therefore located at the cylinder cover level. All fuel pumps, as well as the valves for the starting air, and the lubricating pumps, are operated from a common camshaft, which is chain driven from the crankshaft. A special tensioning bracket allows the chain to be tightened in a simple manner without affecting the phasing of the camshaft. The injection pumps are rated at 1000 atm.

The fuel is heated to reduce its viscosity and all pipes are lagged. Special circuits enable the oil to be circulated to the valves even while the engine is stopped, so that the pipes do not become chilled.

All engine controls are arranged at the forward end, while the amount of fuel injected is set by the governor, the injection position can be altered by hand during running through ±3 deg., in order to allow for variations in the ignition properties of different fuels.



View of engine on test bed showing turning engine in foreground and exhaust manifold (top right)



a—Fuel consumption *b*—Exhaust temperature *c*—Mechanical efficiency
d—Scavenging air pressure *e*—Ignition pressure

Test bed performance curves of "RS 76" diesel engine

The cylinder head is in two sections, the inner of which carries the injection, air and safety valves. Injection pressures are of the order of 500 atm.

The nozzles are strongly water-cooled to prevent carbon deposits. Such nozzles have been successfully used with fuels of up to 6200 seconds Redwood.

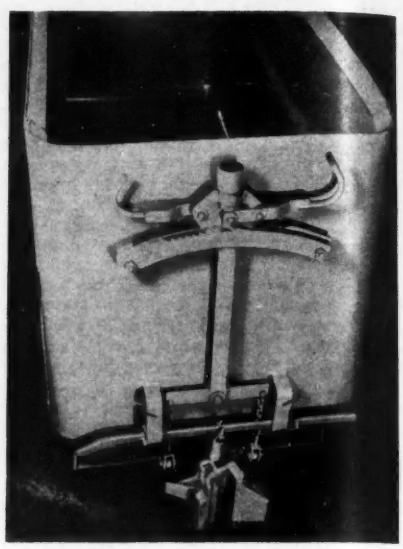
Work is in progress in connection with pressure charging by means of axial-flow compressors, and the company hopes that in a year's time a supercharged twelve-cylinder version with a continuous rating of 15,000 to 16,000 b.h.p. will be ready for testing.

MARINE ENGINE BUILDERS.—At the annual general meeting of the National Association of Marine Engine Builders, Mr. Ewen H. Smith, and Mr. P. L. Jones, were re-elected chairman and vice-chairman, respectively.

Brake-Operating Gear for Mine Cars

DEPENDING upon the arrangements for handling mine cars it is sometimes an advantage to be able to apply parking brakes from one side of a mine car and to release them from the other side of the car without risk to the personnel handling the cars. A brake-operating gear which makes this possible has been designed and put into production by Distinction Engineering Company, Ltd., Workington, and is being marketed under the trade name "Sindex."

As shown in the illustration, it consists of an inverted T-shaped lever which turns on a pivot attached to the end of the car body and which can exert a pull at either end of the cross member. The ends of the cross member can be connected



Linkage for applying and releasing brake of mine car from either side of the car

to almost any conventional arrangement of brake rigging beneath the car. Brakes can therefore be applied to any combination of mine car wheels according to the design of rigging decided upon.

The upper part of the inverted T-lever moves between two arc-shaped racks attached to the car body, and is fitted with two lugs, a double pawl, a coil spring and housing, and two hand levers. The double pawl engages in one rack or the other according to the direction in which the T-lever is pulled, and is held in engagement by a coil spring under compression. On each of the lugs on the T-lever a hand lever is pivoted. Both hand levers are connected to the double pawl.

Brakes are applied by pulling either hand lever, and remain applied by the engagement of the pawl in one or other of the racks. To release the brakes a downward pull is exerted on either hand lever ; the pawl is thereby lifted and the T-lever may be returned to its neutral position. It is therefore possible to release the brakes from either side of the car irrespective of the side from which they have been applied without inserting more than a hand and forearm between two adjacent car bodies.

Lime Works at Silverstreams

GOOD progress is being made in the construction of what eventually will be one of the largest lime works in the world at Silverstreams, about 100 miles west of Kimberley. Production is expected to begin in a few months' time. The plant is being built for the Northern Lime Company, Ltd., and the first stage of the project, estimated to cost £1,200,000, is well under way. This includes the erection of the first lime-burning rotary kiln in Africa, which is more than half completed.

The hard physical quality of the limestone in the Silverstream area is particularly suitable for calcination in a rotary kiln. The capacity of the first stage of development will be in excess of 100,000 tons of lime per annum.

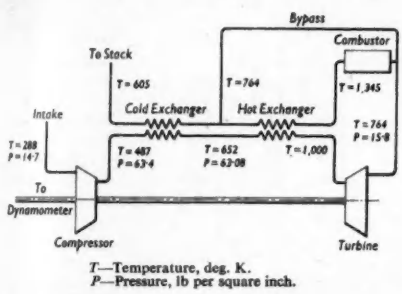
Experimental Coal-Burning Gas Turbine

By PROFESSOR DONALD L. MORDELL, M.A.*

This paper, which was read before the Institution of Mechanical Engineers on Friday, November 5th, describes the experimental coal-burning gas turbine which has been developed largely at the McGill University, Canada. It is the first gas turbine to use the exhaust heated cycle and has a Nimonic tube mixed contra flow and parallel flow heat exchanger. The prime moving elements are those of a Rolls-Royce "Dart" turbo-propeller engine. Large abstracts of the paper are reproduced.

THE only simple way of using coal to produce mechanical work has until recently been the well-known steam engine. The limitations imposed upon reciprocating-steam-engine design, if it is to be included in a locomotive, prevent the attainment of anything like a reasonable thermal efficiency, 5–7 per cent being the usual range. The development of the gas turbine was based on the use of oil or gas as fuel. However, the problems involved in its use of coal do not appear unsurmountable, and when one reflects that both the diesel engine and the steam turbine have arrived at a stage from which it is difficult to see a road leading to major advances, while the gas turbine is really just on the threshold of its development, it seems likely that the successful development of a coal-burning gas turbine might lead to a situation where coal would again be the preferred fuel for many applications.

In his Thomas Hawksley Lecture in 1951, Roxbee Cox outlined the work being undertaken in the United Kingdom on the coal-burning turbine and drew attention to the different ways of approaching the problems. One of the simplest is to adopt the exhaust-heated cycle, and



T—Temperature, deg. K.
P—Pressure, lb per square inch.

Fig. 1—Thermodynamic cycle diagram

this paper describes an experimental turbine operating on this cycle, which has been designed and constructed in Canada by the Gas Dynamics Laboratory, Department of Mechanical Engineering, McGill University, with the support of the Canadian Department of Mines and Technical Surveys.

The Experimental Exhaust-Heated Engine.—In 1950 the author and his colleagues, having made fairly detailed theoretical studies (Mordell 1950; Mordell, Chant and Rogers 1950), suggested that an exhaust-heated engine would offer useful possibilities both for the generation of electrical power in relatively small units, for example, 1000–5000kW, which might be expected to be useful in Canada, particularly on the prairies, and which might also be suitable for installation in a locomotive to produce a coal-burning locomotive competitive with the diesel engine. It had been possible to obtain an obsolete aircraft engine which would provide the essential nucleus of the experimental plant it was proposed to build. The Department of Mines and Technical Surveys of the Canadian Government, which has as one of its responsibilities the development of new uses for coal, considered that that was a project which it could properly support and encourage.

The fact that it was proposed to use an existing gas turbine meant that many of the design conditions were fixed. It was decided to restrict its operation to a maximum speed of 13,600 r.p.m. and a maximum temperature of 1000 deg. K. (1340 deg. Fah.) as compared with the normal maximum conditions of 14,500 r.p.m. and 1100 deg. K. (1520 deg. Fah.). This derating cut down the maximum power to be expected from about 800 h.p. (on oil) to 500 h.p. (with coal), but it was considered essential, not only in regard to conservation of the experimental engine but also because in any event for industrial use no higher temperature than 1000 deg. K. (1340 deg. Fah.) would be contemplated.

The basic problem was to design the heat exchangers, furnace, and ducting necessary to convert the engine to run on coal, and to lay out the plant in a manner convenient for experimental use. At the outset it was decided that in no way was the attempt going to be made to build what might be regarded as a prototype commercial unit, but that the design would be that of a research unit in which every attention was paid to the need to make many measurements, and to a probable requirement to make changes from time to time. Accordingly, plenty of space was allowed for everything and the final arrangement was that shown in the isometric view, Fig. 4. It will be seen that the basic gas turbine is mounted on a steel mezzanine floor where it is coupled up to a dynamometer with which to measure the power and an auxiliary engine to provide power for starting. Manifolds are provided which pick up the compressed air delivered by the compressor, deliver it to the heat exchangers underneath and, in due course, return the externally heated air to the turbine. Behind the turbine will be seen an exhaust duct which takes the exhaust air from the turbine; some of this is by-passed in the overhead pipe to be seen in the figure, while the rest of it disappears underneath the floor to feed the furnace. On the lower floor are mounted the furnace and the two heat exchangers. Immediately beneath the turbine exhaust is the furnace, which will be described in detail later.

The hot combustion products from the furnace pass straight through the first heat exchanger to the far end, at which point they are turned through 180 deg. and joined by the air which has by-passed the furnace and first heat exchanger; the combined stream then passes through the second heat exchanger on its way to the stack which can be seen on the right-hand side of Fig. 4. Fig. 1 shows the thermodynamic cycle diagram.

Hot Heat Exchanger.—The heat exchanger which accomplishes the final heating has to operate at rather higher temperatures than do conventional heat exchangers and accordingly much time was spent on the design of it. Features of the mechanical design and related calculations have been given separately (Rogers and Chant, 1952; Rogers, 1953). The heat exchanger is designed as a mixed counterflow and parallel-flow unit. The use of counterflow is necessary in order to keep the tube area down to reasonable limits and permit the attainment of a fairly high thermal ratio, but at the hottest end the use of a parallel-flow section permits an appreciable reduction in the tube temperatures at the point where they are normally highest. The tube bundle is arranged in an annulus with a blank centre space and this centre space is used as the final transfer duct from the counterflow section to the parallel-flow section.

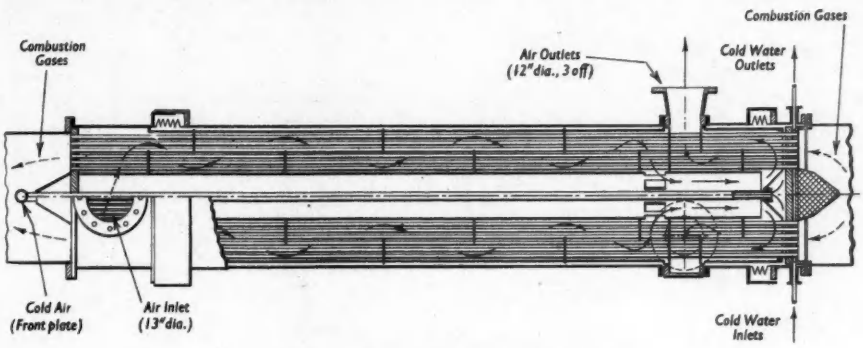


Fig. 2—Arrangement of hot heat exchanger

Fig. 2 is a reproduction of the drawings for the exchanger, and it will be seen that after the end of the counterflow section, the compressed air is forced down into the centre blank part by an intermediate baffle. It then flows towards the front tube plate in the centre duct and is turned through 180 deg. at the tube plate to pass in parallel-flow fashion down the front part of the exchanger. The final take-off nozzles are arranged part-way down. In view of the high temperatures at the hot end of the exchanger, it was considered essential to provide, as far as could be foreseen, complete uniformity of temperatures to avoid the development of hot spots or irregular heating which might lead to expansion and distortion troubles. The use of the centre duct in this connection helps very considerably in providing a uniform flow over the front tube plate [illustrated in the paper], which is the hottest part of the whole exchanger.

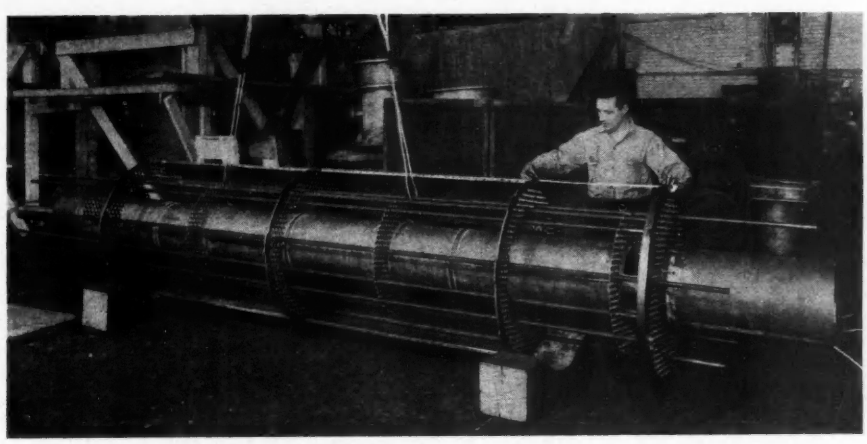
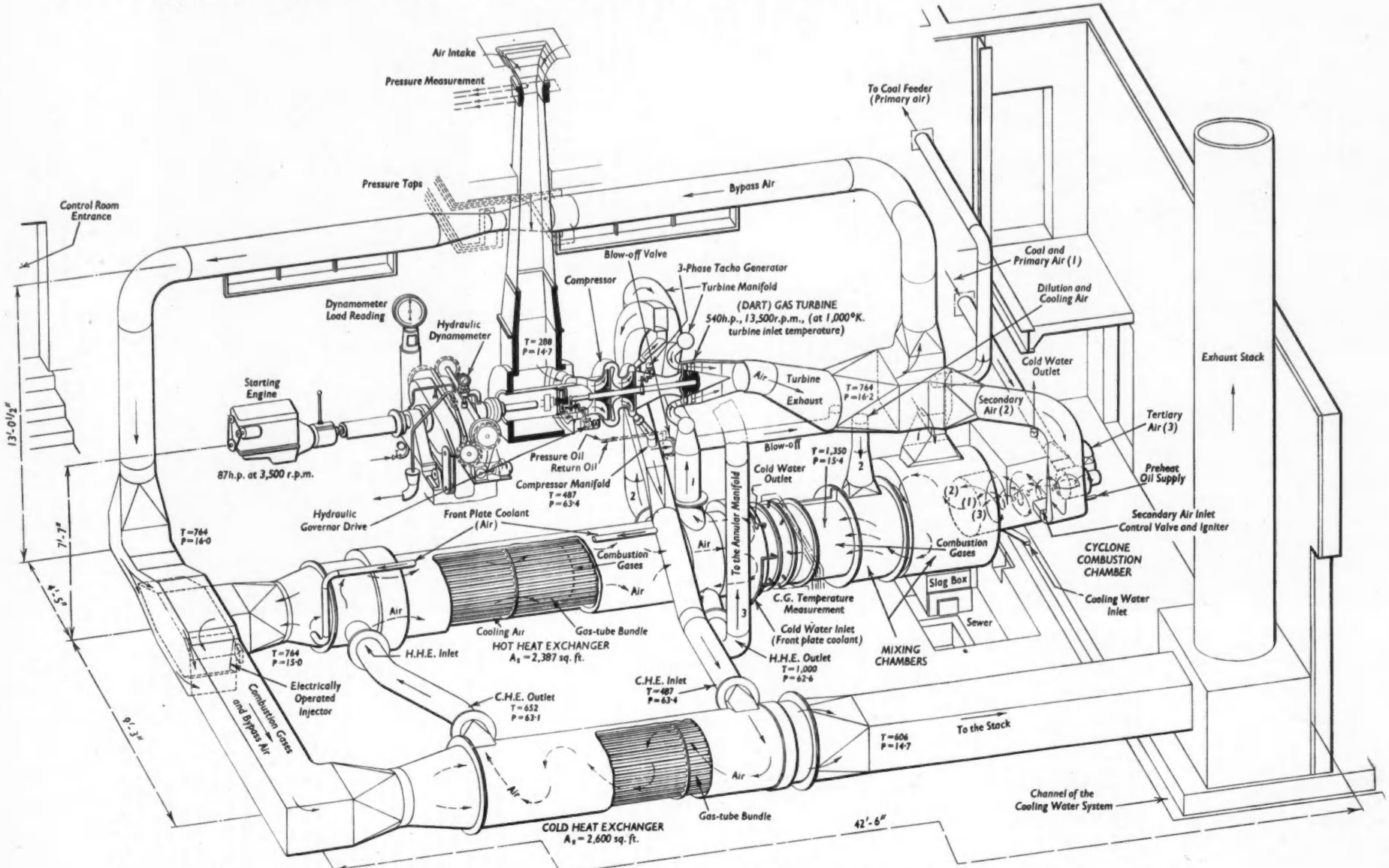


Fig. 3—Tube matrix of hot heat exchanger in course of assembly

* Professor of Mechanical Engineering, McGill University, Montreal.

EXPERIMENTAL COAL-BURNING GAS TURBINE FOR LOCOMOTIVES



T—Temperature, deg. K. *P*—Pressure, lb per square inch. *A*,—Surface area. *C.G.*—Combustion gases. *C.H.E.*—Cold heat exchanger. *H.H.E.*—Hot heat exchanger.

The surface area of the hot heat exchanger of 2387 square feet comprises 400 square feet of parallel-flow and 1987 square feet of counterflow unit.

Fig. 4—Isometric drawing of experimental plant

The front tube plate, which is highly stressed by virtue of the fact that it contains the compressed air and at the same time is subject to extreme thermal conditions owing to the hot gas flowing through the tubes which are rolled into it, led to a special design being adopted. This design involves the use of a double tube plate with an intermediate coolant passage through which air or water can be circulated in order to control its temperature. To design it, it was found necessary to develop new methods of calculation for the temperature distribution in such a system ; that will be referred to later.

The tube material is Nimonic 75, and stainless steels and heat-resisting steels have had to be used in various places such as the front tube sheet and the assembly of the final take-off nozzle. However, the use of heat-resisting steels in the pressure shell has been avoided by the adoption of a system of air cooling which includes the use of an internal stainless-steel liner concentric with the outer carbon-steel shell. In the annular space, cooling air is passed and serves to keep the carbon steel shell at a reasonable temperature after which the cooling air is passed into the heat exchanger to be further warmed and supplied back to the turbine. Fig. 3 shows a view of this heat exchanger taken during the course of its construction.

Cold Heat Exchanger.—The second heat exchanger is quite conventional in every way, the temperatures encountered being not extreme, and its construction being wholly of carbon steel. Fixed tube sheets are used, with a simple sliding expansion joint in the shell at one end.

Manifolds.—To pick up the compressed air and feed the heated compressed air back to the turbine it was necessary to design manifolds. It should perhaps be emphasised that the manifolds, whose design and development have been one of the major difficulties, are not relevant to the coal-burning turbine as such, and were only needed to adapt an aircraft unit for experimental purposes.

Furnace.—The decision was taken to use a cyclone-slagging type of furnace. This has the advantages of having no moving parts, of being well suited for the combustion of low-grade fuels, and for the removal of a large part of the ash, while it lends itself admirably to the use of highly preheated combustion air. An experimental combustion chamber and subsequently, a second furnace was built. Although the combustion performance was raised to a satisfactory level, the mechanical performance was not too good. Fig. 5 shows an isometric view of the redesigned furnace and mixing section which is now installed. The main combustion chamber is a cylindrical vessel, 2ft in diameter, lined with a castable refractory, and water-cooled. The coal which is previously crushed to pass through a ¼in diameter screen is injected with about its own mass of air at one end of the chamber with a swirling motion. The secondary air or the main combustion air supply is fed tangentially to the furnace and when in operation the swirling motion of the air and the coal throws out the coal particles to the wall by centrifugal force. The coal adheres to the wall and is then scrubbed by the rapidly whirling air stream and burnt very rapidly and completely. Owing to the high temperature level in the furnace the ash fuses as it forms and the wall becomes coated with a layer of molten slag whose thickness depends on the temperature level within the furnace. This molten slag drains out through the furnace and is continuously collected.

The combustion gases pass through a throat at the end of the furnace into a secondary chamber where there are two baffles, arranged vertically to serve the dual purpose of catching some of the ash which might otherwise be blown out, and of shielding the heat exchanger which follows from the intense radiation from a very hot primary zone. Excess air, which is not required for combustion, is fed into the hot gases in the wake of these baffles, having first been used as cooling air to cool the brickwork of the secondary mixing chamber. The whole furnace assembly is mounted on sliding runners to permit freedom for expansion.

Coal-handling Equipment.—The raw coal, which is stored in a bunker external to the building, is brought in by truck as required, when it is loaded into a hopper, which has a capacity of about 12 tons, and at the bottom of which is a screw-feeder. This screw-feeder carries the coal out of the hopper and feeds it to the crusher, which is of the swing-hammer type, and which forces the coal through a ¼in mesh screen. The crushed coal is picked up by an air stream which lifts the coal into the roof space of the building where it is separated from its carrying air and deposited in a hopper ready for use. This hopper is scale-mounted, thus permitting measurement of the rate of coal fed by noting the diminution in weight of the hopper and its contents as a function of time. The coal is fed from the hopper to the primary air-line by an air ejector which blows the coal into the primary air-line, and which takes its air either from a plant compressor or a bleed from the turbine's compressor.

Instrumentation and Control.—Because this was a research engine and there were many problems in the heat-exchanger and furnace design on which information was scanty, very full and elaborate instrumentation has been provided. The plant is arranged so that one man has complete control of the plant, and has in his view all instruments necessary to ensure safety of operation of the plant and maintenance of correct test conditions. The other more detailed measurements which are required for research purposes are indicated on panels on each side of the operator and the readings are taken by other observers. About 180 thermocouples are installed to measure important temperatures and some fifty pressure measurements are taken. In addition, there are many observations of auxiliary circuits which require watching and control. To facilitate investigation of transient conditions during warm-up and shut-down, a number of critical thermocouple readings are electronically recorded as a function of time and, in addition, transducers permitting the recording against time of engine speed, power and coal-feed rate have been developed and installed.

Assembly of the Plant.—Actual assembly of the completed installation commenced in August, 1953, following delivery of the hot heat exchanger. The problems of expansion of all the numerous elements of the plant have been taken care of largely by using suspensions rather than supports for all components so that apart from fundamental locating points the support for all members is in the form of tension rods which are free to move laterally under the influence of thermal expansion. Where this was insufficient, expansion joints have been provided in the ducting and the structure is perfectly free to expand without disturbing any of the essential alignments or opening any joints. External insulation has been applied to both heat exchangers and all the ducting and furnace, &c., in an attempt both to keep down the external heat losses and to render the test cell habitable during operation. Owing to space limitations a complete view of the plant cannot be shown, but Figs. 8, 9 and 10, give the best views possible.

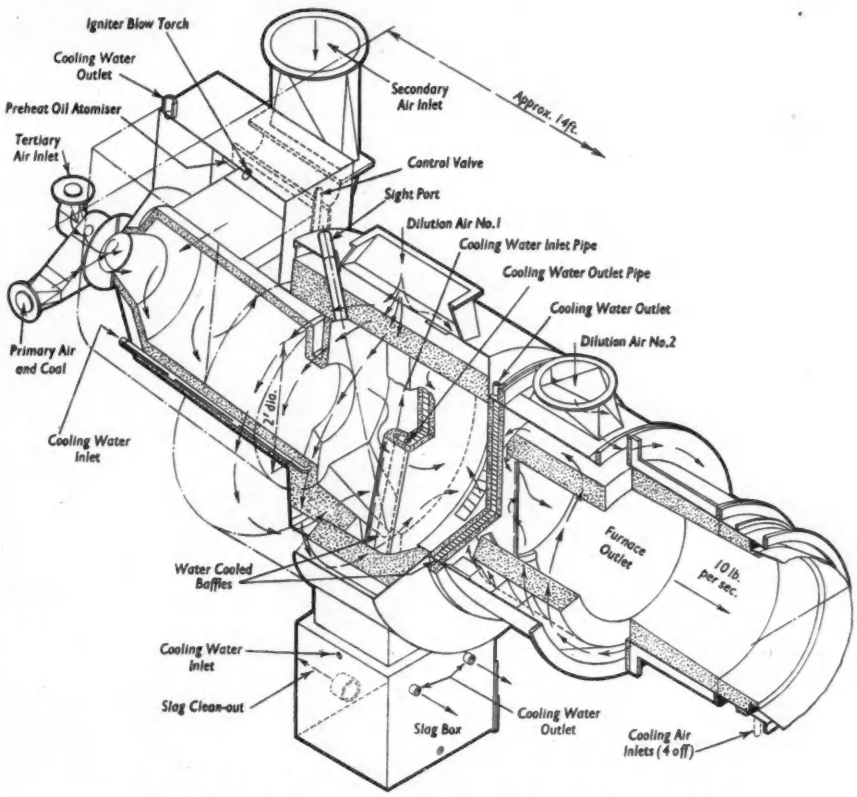


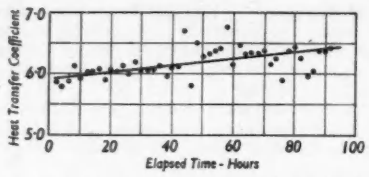
Fig. 5—Isometric drawing of the furnace assembly as used for engine tests

Preliminary Experimental Work

Heat Exchanger.—Two problems that were immediately apparent in the heat-exchanger design were, first, the probable rate of fouling and, secondly, the effectiveness of the cooling arrangements for the front tube plate. Although it was intended to use a slagging type of furnace, part of the ash in the fuel has to pass through the heat-exchanger tubes, and the effect of tube fouling on the rate of heat transfer is not calculable. Accordingly, the Fuels Division constructed a test rig in which conditions of the hot exchanger were simulated in an exchanger with four 1in diameter tubes, 10ft long. This was fired with gases from a small cyclone chamber, in which provision was made to inject extra ash. Tests were made over 35-hour periods with five different coals. The ash remaining in the tubes was found to be non-adherent and could be removed by light brushing. In no case was its amount greater than 2 per cent of the ash in the coal charged. Measurements of heat-transfer coefficients were also made, and the results of a 90-hour test are shown in Fig. 6 (reproduced from Warren and others (1952)). Although there is a considerable scatter, due in part to instrumentation difficulties, it was concluded that ash fouling should not be critical, although final conclusions can be drawn only after prolonged operation of the complete unit.

The design of the cooling system for the front tube plate demanded knowledge of the local heat-transfer coefficients in the entrance length of the tubes, before pipe flow is established,

and also some rather elaborate calculation of the resultant temperature distribution in the tube plate. Again a small-scale model rig was constructed and tested (Rogers, 1953). For the transfer coefficients some very interesting results were obtained, which suggested that at high temperatures existing data were not too satisfactory. Fig. 7 shows a plot of values of local heat-transfer coefficients as a function of x/d, the length/diameter ratio. It will be noted that the values are considerably higher than those of other workers and in view of the importance of this to the design, a considerable study was made. It was suspected that turbulence was a factor, but it was found that in tests at the same Reynolds number, measured values



The heat-transfer coefficients are expressed in Centigrade heat units per hour, per square foot per degree Cent.

Fig. 6—Results of heat-exchanger fouling tests

showed a trend to higher values as the absolute temperature increased. This is discussed in detail in the reference cited.

The application of these data to the determination of the temperature distribution in the tube plate required the development of a rather elaborate theory. To check this, a model of the front end of the heat exchanger was built, using seven mild steel tubes of $\frac{1}{16}$in outer diameter, 20 Birmingham gauge, expanded into a $\frac{3}{4}$in thick mild steel tube-plate, and arranged on a $\frac{1}{16}$in equiangular pitching. The cooling passage in the tube plate was $\frac{1}{4}$in, and the tubes were fed with hot air from a gas-fired combustor. The measured temperature distribution in the plate was compared with that calculated by means of the data referred to above; some typical results are given in Fig. 11, and show a reasonable agreement. This gave confidence in the design of the full-scale exchanger. It will be observed that allowance for the variation in local values of the heat-transfer coefficient, as determined in the earlier tests (Fig. 7) makes about 10 per cent difference in the predicted values and brings them within about 10 per cent of the measured value.

Furnace.—The cyclone burner already described above appears to offer the neatest

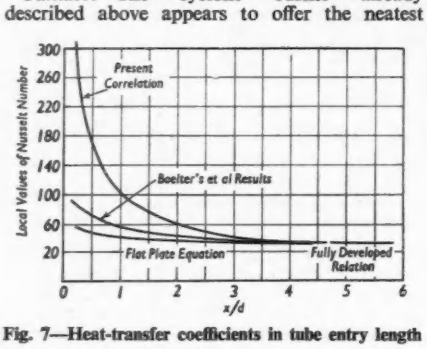
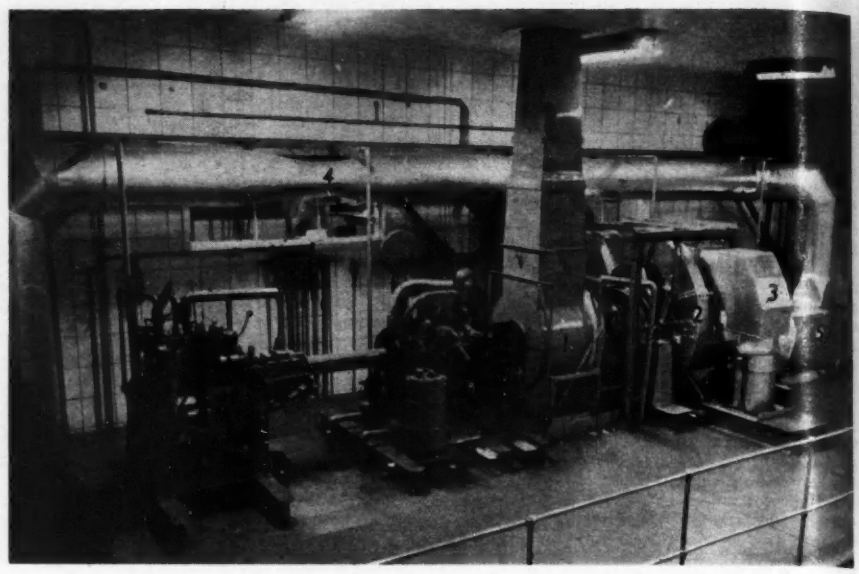
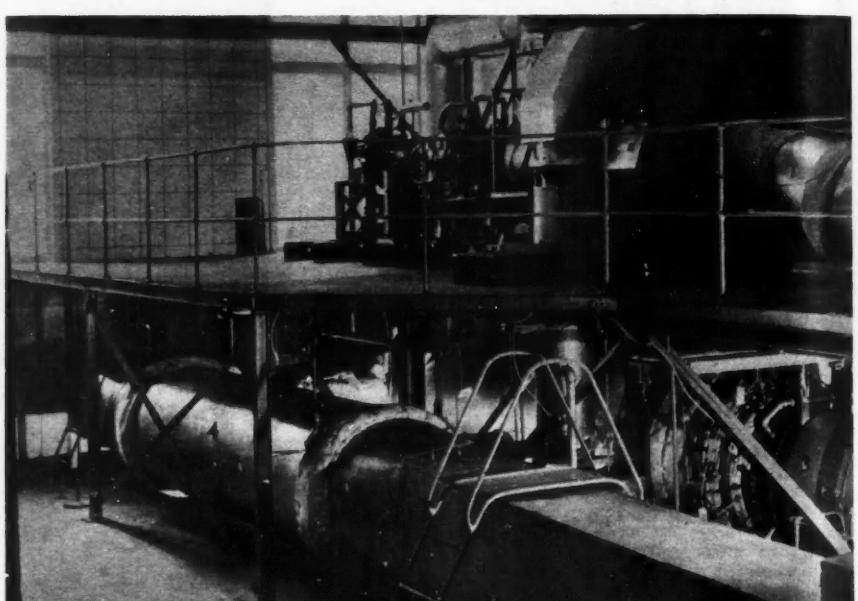


Fig. 7—Heat-transfer coefficients in tube entry length

solution to the actual coal-burning problem (Wilcoxson, 1947). After some initial testing, the Fuels Division built a cyclone (shown diagrammatically in Fig. 12) and ran preliminary tests. With the test facilities then available in Ottawa this could not be tested under all the necessary conditions and a similar furnace was constructed in the University laboratory, and supplied with the exhaust from the "Dart" turbine, then burning kerosene. By loading the turbine, any desired preheat temperature to the furnace could be obtained. The only difference between this set up and that intended for the full plant was that the combustion air was deficient in oxygen, having been heated by internal combustion. A programme of tests was carried out. They have been reported in detail elsewhere (Mordell, Chant and Foster-Pegg, 1953) and may here be summarised by saying that they proved that good combustion



(*a*) Starting engine, dynamometer and turbine.
(1) Air-entry plenum chamber. (2) Compressor manifold. (3) Turbine manifold. (4) By-pass-air venturi meter. (5) Turbine-exhaust header duct.



(*b*) The two heat exchangers.
(1) Turbine-exhaust duct. (2) Hot heat exchanger. (3) Ducting between furnace and hot heat exchanger. (4) Cold heat exchanger.

Figs. 8 and 9—The completed plant

could be achieved, but that heat losses were large, and that the construction was unsuitable mechanically.

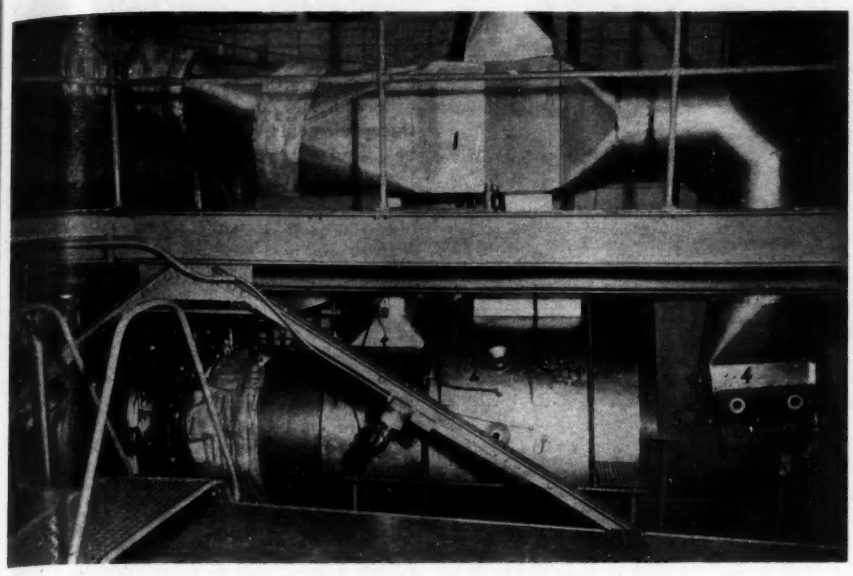
The test programme was interrupted before the end of the planned period as a result of a minor breakage in the engine, and it was decided to abandon both the test series and the original design of furnace mixing section, to use the results so far obtained to design the improved mixing section shown in the isometric view of the furnace (Fig. 5), and to run this for engine tests without any further rig tests.

Initial Engine Testing

On November 20, 1953, the engine was run under its own power for the first time, with oil used as the fuel, and was subsequently run for five hours at 10,000 r.p.m., and at 900/1120 deg. K. (This convention is used here and subsequently to indicate first the turbine-inlet, and secondly the furnace-outlet, temperatures.) After inspection the plant was run again on oil for five hours on November 27th, at 12,000 r.p.m., 900/1130 deg. K., and the fuel was then turned to coal and a run of two hours on coal at 11,500 r.p.m., 870/1070 deg. K. was made. These two runs are believed to be the first runs of an exhaust-heated gas turbine on oil and coal, and it marked the completion of the first phase of the work.

The second phase, which took longer than expected, was to clear up the teething and other preliminary troubles before starting serious development and endurance running.

Most of the troubles experienced have been with the turbine manifolding and expansion joints and this accounts for the long time taken since a fairly complete dismantling is necessary to make any modifications. The basic difficulty is that the turbine, being originally designed as an aircraft engine, has a very light turbine shroud ring, and only a small load transmitted from the manifold through the expansion joints is liable to distort it and cause it to bind on the

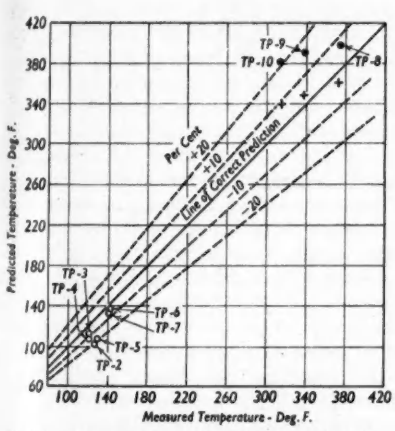


(c) Furnace and mixing section.
(1) Turbine-exhaust header duct. (2) First-stage mixing section. (3) Second-stage mixing section.
(4) Secondary (combustion) air entry to cyclone. (5) Water-cooled cyclone furnace.

Fig. 10—The completed plant

turbine blades. Curiously enough, this is a trouble which has only occurred many hours after the plant has been shut down.

In its original form the furnace behaved fairly well from the combustion viewpoint except for some difficulties with slag freezing, due largely to the relatively small amounts of coal being burnt and the low ash content of the coal used. It is necessary to ensure that there is no possibility of the coal coking immediately at the furnace entry. On two occasions, when modifications to the coal-injection system were being tried, this has happened. In these circumstances, the coal may get into the ducting and on one occasion a fire took place in the by-pass duct, which overheated the cold heat exchanger, fortunately without doing serious damage. To prevent any further occurrence a temporary



Prediction by using mean gas heat-transfer coefficient :
O—Water-cooled runs.
●—Air-cooled runs.
Prediction by allowing for variation of gas-heat transfer coefficient:
+ Air-cooled runs

Fig. 11—Comparison of measured and predicted tube-plate temperatures at different positions at one value of gas temperature (small-scale rig)

modification was made to the coal-entry feed, a simple axial entry being used.

No significant troubles have yet been experienced with the heat exchangers and, after the first fifty hours, the tubes showed no sign of any ash deposition. In the hot exchanger it was found that the effects of radiation from the hot tubes on the temperature of the carbon steel outer shell had been underestimated. When the exchanger is stripped down, extra internal insulation will be applied to correct the over-heating, but for the present a water-cooled pad has been applied to the critical region to avoid the delay, at a small cost in heat loss.

The air-side pressure loss was found to be higher than expected and analysis showed that the baffling was too close. This again will be rectified when the exchanger is stripped.

Although it was known that slag removal was still not perfect it was decided to give the plant an extended run to prove it mechanically : a non-stop run of fifty-seven hours was made. It was found that, when the coal-feed rate was

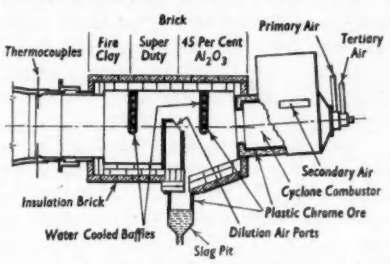


Fig. 12—Furnace and mixing section as originally rig-tested

increased beyond that used in the tests with the restricted "Dart No. 8," the temporary coal injector was not satisfactory, and blew most of the coal beyond the cyclone so that, in fact, it was mostly burning in the mixing zone. Also, as was half expected, the slag drain froze up again. The trial run was, however, continued as it was felt that it would be a severe test of the heat exchanger under the most adverse conditions that could possibly be anticipated in service. The run was completed without any troubles, the power output varying up to 250 h.p. and turbine-inlet temperatures up to 1000 deg. K.

At the conclusion of this test a total of 114 hours had been run, including nine starts and stops (two of the stops being emergency stops), and many rapid changes of load had been made so that all representative running conditions had been met. Throughout this period, although much work was done on the turbine manifolding and location, the heat exchanger received no attention whatsoever and the only maintenance on the furnace was to chip out slag. It was felt that the second phase of activities, namely, preliminary proving tests of the plant, had been accomplished.

The third phase, comprising development to ensure continuous slag removal from the furnace, satisfactory coal-feeding and long-period endurance running at incremental powers, is now in progress, and will be reported in due course.

Conclusions

Final conclusions concerning the practical possibilities of the exhaust-heated cycle must await the results of protracted operation, but from the work so far done a number of important points are obvious.

It has been demonstrated that coal can be used as a gas-turbine fuel using the exhaust-heated cycle. In spite of the large thermal capacity of the heat exchangers, the plant can be started from cold reasonably quickly. It can accept or shed load quite fast, because the load can be changed by changing turbine speed and air flow, without much change in tube temperature and, therefore, in stored heat. In emergency, it can readily be shut down. A blow-off valve, which is controlled by an overspeed governor, with a manual over-ride, has been used on the compressor delivery, and this system has proved satisfactory.

It is felt that the exhaust-heated unit is in no way temperamental. It does not require careful nursing and maintenance and has already demonstrated its ability to run, even though combustion was far below the standards which it was known, from the rig tests, could be achieved.

The immediate programme is to run about 500 hours and then strip the heat exchangers and furnace for a complete inspection. At this time the hot exchanger will be modified to rectify the shell cooling and air-side pressure loss, and the plant will then be reassembled for further continuous running.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GRAPHICAL SYMBOLS FOR ELECTRICAL PURPOSES

Users of circuit diagrams find it convenient to define classes of components and to identify particular components in a class, by employing code letters or component references. For this purpose "power" engineers employ the symbols given in the 1951 edition of B.S. 108 (Graphical Symbols for General Electrical Purposes), while telecommunication users consult the Supplement to B.S. 530 which was published in March, 1950. Each standard reflected the conventions that had grown up in the field of technology concerned, and in consequence there were some inconsistencies between them. For instance, a capacitor was Cp in B.S. 108 and C in B.S. 530, C being a contactor in the former. In power diagrams TR indicated a tripping relay, but in telecommunication diagrams it indicated a transformer. As a result of much discussion between technicians in both fields these differences have now been removed ; the simultaneous issue of amendments PD 1952 (to B.S. 108) and PD 1953 (to the Supplement to B.S. 530) show the extent to which the two classes of users have met half-way. As examples, a capacitor is now C to all users, a contactor being Con. TR remains tripping relay, the transformer of B.S. 530 having become T to conform to B.S. 108.

ROSIN-CORED SOLDER WIRE "ACTIVATED" AND "NON-ACTIVATED" (NON-CORROSIVE)

No. 441 : 1954. Price 3s.—This is a revision of the standard published in 1932. Since that date methods of activating the rosin-core of the solder have been developed, and the new edition specifies solder wire with a core or cores, incorporating the advantages of these methods. The scope of the standard has been widened by the inclusion of five grades of solder, for each of which information is given with regard to melting characteristics and typical uses. In addition, tests have been included relating to the hardening of the flux residues, and to their freedom from corrosive action.

Firm's Golden Jubilee.—We have received from The Spiral Tube and Components Company, Ltd., Osmaston Park Road, Derby, a copy of an illustrated brochure which it has produced to celebrate its golden jubilee. The firm was founded in 1904 by Mr. Francis Edgar Bennett for the production of spiral tubing from metal ribbon in a small workshop in Caledonia Street, King's Cross, London. The foundation stone of the firm's factory in Derby was laid in 1914 and on several occasions since then that factory has been extended. During the same period the firm has established a London works at Honeypot Lane, Stanmore. The brochure records not only the growth of the firm's business during its first fifty years but also gives some interesting details of the many applications of its products.

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DISCOVERY AND INVENTION

It is often held that, high as is Britain's repute in the world of science, our application of discoveries is slow, far slower, for instance, than across the Atlantic. Fortunately this possibility is being realised and the Government and other bodies are seeking means to increase our annual output of highly trained technologists and to facilitate, as through the work of the National Research Development Corporation, the transition from inventive ideas to marketable products. But because specialisation has been pressed so very far, it must be confessed that our predecessors would probably have obtained far higher marks in a " General Knowledge " examination paper on professional topics than would their grandsons to-day ! That such a confession may have to be admitted is a challenge to us to ask whether it must be so. Is it because the field to be covered is so much wider ? Or that, in the circumstances of a " cold war " atmosphere, free and ready disclosure of many new technical adventures must needs be limited ? But is it not also true that the opportunities for scientists to make their important advances seem often, nowadays, to be found in the boundary areas between two or more sciences in which a specialist is liable to find his knowledge somewhat thinly spread ? Those questions pose no merely academic problems ; for upon the finding of the right answers may depend the ability of our profession to keep ahead in its output of discovery and invention.

During a recent scientific conference at Imperial College, the relation between fundamental research and its practical applications was one of the topics debated, and the point was made that practical advances were commonly the outcome of direct experimentation having a definite aim, rather than the result of an exploration depending on the slower processes of the scientific procedure by hypothesis, experiment and deduction, the merit of which would seem to lie rather in its widening of the bounds of basic knowledge and so revealing promising points for the practical ends sought by the engineer. Those ends cannot, however, always be clearly seen, and it was remarked by one speaker that even so good a scientist as the late Professor Karl Pearson did not see that the discovery of radio waves would immediately serve any useful end ! The recent Oxford meeting of the British Association was marked by the attention paid to fundamental questions, due, it may well be, to the example set by Dr. Adrian, its eminent President (and President of the Royal Society), who stressed the point to which we have already referred that the important fields of discovery to-day tend to arise in the boundary areas between the technical and scientific studies which at one time used to be so clearly bounded as to be almost mutually exclusive. In the early days of physics there was no great difference between the experimental and theoretical branches, nor any division of physicists into two distinct groups, but it is now hard for any one man to be a master of both techniques. The two sides can, however, unite, as has in recent years been seen with startling effectiveness in the study of the liberation of nuclear energy. Not so many years ago it was only feasible to study the disintegration of natural radioactive elements, such as radium, which result from the decay of parent substances. But such decay products must needs be somewhat rare, or very inactive, or they would have already disappeared during the earth's history. Some, such as uranium and thorium, must needs have a half-life comparable with the age of the earth ; these we can study by bombarding their nuclei and observing what happens. As a result of recent advantages—it is less than a decade since the first atomic bomb exploded—radioactive isotopes have already become widely available in medical research as tracer elements, and have lately begun to be found of use in engineering industry in leak detecting, for thickness gauging, the study of wear due to friction, &c. Looking ahead it is permissible to wonder whether it may be possible to extend considerably the use of the radioactive waste products from nuclear reactors for assistance in certain industrial processes that arise in chemical engineering or to find a quicker way of obtaining power from the fission of the atomic nucleus than employing it to produce steam power for use in the driving of electric generators. Many other applications will no doubt follow. However surprising some of these may be, they can hardly prove more so than the existence nowadays in so many physics laboratories of the huge pieces of apparatus needed for the study of the processes involved—such as synchrotrons, and their like—which can dwarf even the largest apparatus commonly found in laboratories devoted to engineering studies.

But even when laboratory requirements are of quite modest dimensions the results can be remarkable. One such was briefly reported, in our issue of September 3rd last, as the outcome of a visit to the research laboratories of The General Electric Company at Wembley to see the work there being done on the study of semi-conductors. Some of it had an almost dreamlike quality ; to wit the creation of a block of germanium in which one portion has an avidity for gathering electrons, and the other is as keen on turning them away ! The method of rectification so arrived at opens a new field of minute scale mechanical construction having very numerous uses ; although the full exploitation of their electromagnetic photo-electric and thermo-electric qualities may well lead to ends hard to foresee and perhaps untimely to forecast. Dr. Willis Jackson in his presidential address to the Engineering Section of the B.A. offered some remarks on such developments. The amounts of impurity, such as antimony or arsenic, on the one hand, or indium or gallium, on the other, which are used may be as little as a few parts in a hundred million of the germanium, and such transistors and the like promise to be of real service in submarine cable repeaters, in guided missile controls, and in the complex components of electronic computers. There has, since the end of the second world war, been a marked change in the view industry takes of the value of electronic apparatus. It is finding its way into British factories for the control of machinery and for the automatic inspection of some of its products. This can be done with a speed and accuracy much ahead of manual control. It is upon the use of electronic apparatus that the conception of the " automatic factory " is founded. Moreover, the computing methods available through the development of electronic apparatus are so amazingly rapid and precise that it is small wonder that the public and private institutions so equipped are booked up far ahead with the problems set to them by industry.

PRIORITIES IN CAPITAL EXPENDITURE

In much recent discussion and comment upon the continuing expansion of Britain's economy doubt has been expressed whether this country is devoting nearly enough of its total product to new investment. Figures published in the *Bulletin for Industry* some six months ago, for example, indicated that investment per head of population here has been running in the last few years at very little more than one-third of that in the United States and even somewhat below that ruling in Germany; not a happy situation for a country that must depend on its efficiency in production if it is to maintain its competitive power in export markets. Moreover, something like one-half of the capital expenditure is being devoted to housing, which, though it may have some relevance to productivity by improving the mobility of labour, has a far less direct effect than investment in industrial plant, machinery and buildings. There is, too, the further point that latterly there has been a pause in the expansion of manufacturing plants. Manufacturing industries, for one reason or another, have been spending less than they did two or three years ago on new shops and new equipment. It is true, of course, that there are special reasons for this country's relatively low capital expenditure since the war. Immediately after that conflict it was necessary, as rapidly as possible, to increase exports in order to pay for food and raw materials, and little industrial capacity could be spared for the re-equipment of home industries. Then, just when output had been pushed sufficiently high for a larger surplus above export needs to appear, the Korean war necessitated a diversion of productive resources to re-equipment for defence. But now, the national product having increased by some 7 per cent between 1950 and 1953, and having reached, probably, a level today higher than it has ever attained before, a new opportunity has occurred to expend an increasing fraction of the total national income on capital improvements.

Once, however, it is admitted that more money can and should be expended upon re-equipment a new question arises. The amount available will, of course, always be limited in relation to the suggested uses for it; and in these days we have travelled very far from that *laissez-faire* system under which no conscious national decisions had to be made since individuals and smaller authorities were left to decide matters for themselves. What are the priorities that should rule in deciding how the capital should be spent? Some important vestiges of the *laissez-faire* situation still, of course, remain. When Mr. Butler remarked at the recent Lord Mayor's dinner to bankers "The need to-day is for farsighted decisions to expand capacity and increase efficiency by an ever-increasing use of modern machinery and new techniques," he was encouraging individual firms to plan boldly and to invest out of their own resources or from capital saved elsewhere in new plant and machinery chosen by themselves. When he introduced investment allowances in his Budget of last April he had the same idea in mind, that of encouraging individual firms to make their own individual decisions. But over very important sections of the economy the Government directly or indirectly has control of capital expenditure. What priorities ought to rule there? Would it be right, for example, to continue to permit the expenditure of large sums on the development of the iron and steel, coal, gas and electricity supply industries whilst devoting very little to the construction of improved roads or to the modernisation of railways? To what extent should local authorities be now encouraged to expend more on, say, sewage purification? How quickly should the equipment of hospitals be allowed to improve? Should there be officially more encouragement than heretofore for the building of offices and commercial premises? How soon can the country afford to make a start upon the erection of such structures as the Severn bridge? At the moment there is more than a suspicion that priorities for capital expenditure are fixed more by the clarity with which the need for them can be seen than by any constructive planning as to what should really come first. For example, shortages of coal, steel and electricity, all three the products of industries particularly favoured for capital development, have immediate and very obvious effects upon national production. Yet inefficient roads and railways which have no such striking repercussions upon industrial output may, for all that, even more actively impede the raising of productivity and the lowering of costs. Neither should the influence of satisfactory office premises in encouraging high output be underrated, indirect though it is. Nor can we feel very certain, quite indefinite though the connection may seem, that holding back the modernisation of sewage works may not also have undesirable repercussions upon industrial output.

In a recent newsletter Sir Stephen King-Hall asks in effect "Who plans what and why and how?" As the Government now has so large an influence upon the way capital is expended, the question has point. How are priorities for capital expenditure decided? Of course, politics have some influence. It may well be true, for instance, that in the best economic interests of the country too much effort is being put into house building. But what Government to-day could afford deliberately to cut the housing programme? Yet over a very wide field no such political factors can or should rule. Decisions should be made on rational as much as upon humanitarian or electoral grounds. Like the Operational Research Society, which recently commented in its "Quarterly," we find it "hard to see how a sufficiently objective assessment could be made by other than scientific methods." It is true that the subject is of such complexity that full confidence in the ability of operational research methods to find the right answers cannot be expressed. For humanity plays strange tricks with logic. For example the burning of raw bituminous coal in domestic grates is widely proclaimed to be an inefficient and wasteful means of warming a room and is certainly creative of smoke palls and smogs. But the public seems to regard the cheerful flicker and glow of coal flames as adequate recompense for those ills. Logic goes by the board. Emotion appeals more to the masses than does science. Yet since operational research methods have already proved their value to several of the nationalised boards, not to speak of certain large firms which have intricate problems of organisation to solve, they might well be given a trial.

Literature

Jane's Fighting Ships, 1954–55. Edited by R. V. B. BLACKMAN. London: Sampson, Low, Marston and Co., Ltd., 25, Gilbert Street, W.1. Price 84s.

YEAR by year *Jane's Fighting Ships* continues to maintain its reputation as an up-to-date and reliable work of reference on the world's navies. The 1954–55 edition, which has 2500 illustrations, including 380 new photographs and 155 drawings, is of particular interest in the evidence it gives of the application of scientific and engineering developments to new warships. The foreword, drawing attention to the principal ships and recent developments in each navy, refers to a new type of battleship as a possible future requirement—a ship specially designed to carry a large number of long-range surface-to-surface guided missiles and the heavy armour required to protect her against similar missiles used by the enemy. Later, in the section on the United States Navy, *Jane's* states that a battleship, three heavy cruisers, a carrier and several submarines have been converted, or partly converted, to guided missile ships. The most suitable vessel for this kind of armament would seem to depend mainly on whether atomic explosive is to be used and to a lesser extent on the range at which naval actions are to be fought. A relatively small rocket with atomic explosive would have all the destructive power required, but only a small range owing to the reduced amount of fuel it could carry. With conventional explosives, however, warheads would require to be armour-piercing, thus needing large rockets to carry them and a large ship to carry a worthwhile number of missiles.

For several years after the war *Jane's*—in common with other works of reference—suffered from the difficulty of obtaining reliable information of the Soviet Navy. This new edition, however, is surprisingly accurate, for the figures given of the number of Russian cruisers, destroyers and submarines differ very little from the recent Admiralty estimate, which must have been issued a considerable time after *Jane's* went to press. Only in regard to the submerged speed of Russian submarines, recently built or under construction, is there any ground for criticism. They are all said to be snort-fitted; indeed, there is no evidence from any source that they have an atomic plant or a closed-cycle Walther engine using hydrogen peroxide. To credit them with a submerged speed of 16 or 17 knots without qualification is thus misleading, for they could only maintain it for less than an hour—long enough to give good hope of evading anti-submarine vessels built during the last war—when their batteries would be exhausted. *Jane's* estimate of the Soviet Navy—as now confirmed by the Admiralty—must be alarming to all who realise that this great nation of ours became great by sea power and will only remain great by sea power. How can our twenty-three fast-ageing cruisers—none with a gun larger than 6in and most of them war weary—defend the ocean trade routes against thirty modern Soviet cruisers, many with an armament of 7·1in guns, and any number of armed merchant raiders? More than half-a-dozen cruisers had to be detailed during the two

world wars to round up a raider loose on the trade routes. Nor do we even seem able to retain the ships we have. The cruiser "Nigeria" has recently been sold to India and, according to *Jane's*, two ferry carriers and nine wartime frigates are now to be scrapped. The latter might still have been useful for locating submarines armed with guided missiles.

The Admiralty must envy the U.S. Navy Department, which seems to have no difficulty in obtaining Congress approval for more ships. A fourth super-aircraft carrier of 60,000 tons is now to be built and, according to *Jane's*, the U.S. Navy is planning to bring the number of these giant carriers up to ten. A study of the pages dealing with the Dominion Navies shows that the Royal Canadian Navy has replaced the Royal Australian Navy as the second strongest Dominion Navy. Both have one aircraft carrier in service and another under construction in the United Kingdom, but with the scrapping of the "Australia" and "Shropshire" the R.A.N. is now left with only one cruiser—the "Hobart"—which is being converted into a training ship. Only three "Daring" class ships, instead of the four originally planned, are to be built, and the programme for new and converted anti-submarine frigates has been substantially reduced. The R.C.N., on the other hand, is rapidly increasing in strength and will soon provide a substantial addition to the sea power of the Commonwealth and of N.A.T.O. Apart from her two cruisers in commission, Canada is building fourteen fast anti-submarine frigates and converting twenty-one "River" class frigates for anti-submarine duties. All her seven "Tribal" class destroyers have also been modernised and re-armed for anti-submarine work.

Hydraulic Systems and Equipment. By R. HADEKEL Cambridge: Cambridge University Press. Price 18s.

A GOOD practice for book reviewers is to state immediately whether the book in question can be recommended or not; it can be stated that Mr. Hadekel's book can be recommended unreservedly. The book, according to the publishers' label, is intended "for designers, shop foremen and maintenance engineers and all who use hydraulic machinery . . . ." This should not be taken as implying that the treatment is elementary. Indeed, the trained engineer is more likely to find the book of interest than the average shop foreman, although a knowledge of mathematics is not required to understand it. The book is well and competently written and the author's experience enables it to be authoritative. His style is excellent, lacking verbosity, although sometimes a little difficult to follow without some concentration.

The treatment is mainly of principles of hydraulic equipment. Little information on constructional design features is given although what is given, is important and useful. Both system arrangement and component construction are covered. Separate chapters deal with such specialised hydraulic problems as pump idling, pilot and electrical control, sequence systems, energy storage, system characteristics with variable and fixed delivery pumps, and there are chapters dealing with individual valves, &c. The information on systems includes descriptions of all types, including complex circuits such as are used on machine tools. This particular section is very useful and probably includes much information that has not been published often elsewhere.

Servo mechanisms are not discussed except in so far as reference is made to some of the components used with them. In particular, there is a valuable section dealing with slide valve design, which includes reference to the latest work on valve friction and carries a good bibliography. The author is quite right in stating that the theory of servo mechanisms "is far too complicated to be even sketched out here."

The standard of publication and the printing of text and diagrams are excellent, although the use of heavy "blocking" in the figures is not always attractive; for example, Fig. 72 with a "blocked in" piston is less comprehensible than Fig. 73 where "hatching" is used. This book can be confidently recommended to all interested in hydraulic equipment, whether for machine tools, aircraft, tractors, vehicles, &c. Not the least attractive feature of the book is its reasonable selling price.

Electric Traction. Third edition. By A. T. DOVER. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 60s.

THE first edition of *Electric Traction*, by Dover, appeared thirty-seven years ago and, together with the second edition in 1929, had a wide circulation. The scarcity of good literature on the subject and the growing general interest will ensure a still wider circulation of this third and modernised edition. The author's academic background would suggest that its main appeal will be to the student, and a careful perusal leaves no doubt of this—the examination questions and answers and the various problems worked out will certainly be very welcome in that quarter.

Literature dealing with technology as against engineering principles inevitably becomes obsolete and for this reason the engineer taking up electric traction as a career will not benefit by this book so much as the student, but he will find the various references useful and perhaps regret that they are not more prolific. The student, and, to a lesser extent, the electric traction engineer, will find the numerous illustrations and diagrams useful, but as some illustrate obsolete and some existing practice, an indication of period would have been invaluable.

Accuracy in the production of speed-time and distance-time curves is the basis of much of electric traction engineering, and it is disappointing to find that only an approximate method which produces consistently optimistic results is described—no mention being made of the classical method which involves no approximations. Alternating current traction, particularly the single-phase, 50 cycles version, is now very topical and likely to remain so, and the quality of the chapter on single-phase traction motors will make it very useful to the student and to many engineers who refer to the subject after a lapse of time. The electric traction engineer will, however, often be in difficulties if he accepts all the statements and opinions given by the author, many of which would not be endorsed by railway engineers with first-hand experience of the subject. The latter part of the introduction is particularly open to criticism in this respect.

The book covers a very wide field and some people will think that the omission of the very specialised technology would have allowed more space for fundamentals and treatment of some of the many problems electric railway engineers have to deal with from time to time. Summarising, the main appeal of the book will be to students and those who wish to get a general view of electric traction. The engineer who has taken up electric traction as a career will use the book less and will not find recorded the results of hard experience that so often make the difference between success and failure—electric traction being so very empirical as is all railway work.

Engineering Analysis. By D. W. ver PLANCK and B. R. TEARE. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 48s.

IN his 1953 lecture on "The Training of Engineering Designers" (THE ENGINEER, May 22, 1953, page 736) Professor M'Ewen remarked that "the ordinary technical training of the engineer equips him with an armoury of analytical weapons with which to attack the technical problem which has been precisely formulated either in terms of an examination question or of a project for experimental investigation. But, in fact, the most difficult part even of analysis of real situations is the formulation therefrom of a problem sufficiently precise to be successfully attacked and sufficiently complete and representative for the solutions to be valid and useful." The aim of Professor ver Planck and Dean Teare is precisely to train the student in what they call "professional method"—that is, the ability to approach a problem logically and systematically and to apply fundamental principles and engineering judgment to a situation which may be stated in broad or even vague terms. This he will undoubtedly have to do when he is in industry and if universities can successfully incorporate courses of the type covered by this book, there is no doubt that the graduate engineer will both be a better man and also more immediately useful in industry. It is to be hoped that courses of the type which the authors give at Carnegie Institute of Technology will become common.

As "operational research," originally a military technique, has spread into many fields, the "professional method" is found to have much in common with the military "appreciation"; this is not, perhaps, surprising, except to those to whom the military mind appears unscientific. There is also a strong resemblance to the "technique of design" advocated, in his book of that name, by Mr. P. J. Wallace: his "analyse, theorise, delineate, modify, draw," are paralleled by the authors' "define, plan, execute, check, learn and generalise." The parallel goes further—both books emphasise the importance of checking, the necessity to keep in mind the real objective—"what are we trying to do? Why are we trying to do it, anyway?" and the value of continually trying to see whether the answers are reasonable. This is a bigger book than Mr. Wallace's and the examples are many and varied; but there is a common philosophy.

The authors give instruction and examples on defining the problem, deciding what principles to apply, translating into mathematical language, checking, understanding and interpreting the results. The examples are drawn from all branches of engineering, including dynamics, heat transfer, electricity and magnetism, and the mathematical techniques employed include power series, hyperbolic functions, graphical and numerical integration, and linear differential equations with constant coefficients, both homogeneous and non-homogeneous. It makes no attempt to be a textbook on either the engineering theory or on the mathematical techniques, but treats all the topics from the point of view of understanding what is really at issue. A single sentence from Chapter 4 will serve to give the standpoint of the whole

book : " Mathematics has inestimable power for increasing your capacity for making logical deductions from a set of facts, but it cannot supply the facts nor can mathematics distinguish between right facts and wrong ones." The selection of the right data for mathematical attack is the art of engineering analysis.

Catalogue of the Scott Collection. Compiled by BETTY M. COOPER, A.L.A. London : The Institution of Naval Architects, 10, Upper Belgrave Street, S.W.1. Price 42s.

IN 1711 there was founded the firm whose present title is Scott's Shipbuilding and Engineering Company, Ltd. One of the descendants of the founder of that firm made the collection of books, manuscripts prints and drawings which is the subject of this catalogue. John Scott was born in 1830 and played a prominent part in the development of the arts of shipbuilding and marine engineering. In 1858, for example, he built for test purposes the " Thetis," an iron ship which was equipped with " Rowan " water-tube boilers. As early as the " sixties " he fitted a water-tube boiler in a French corvette, and he took a prominent part in the development of compound steam engines. He was one of the earliest members of the Institution of Naval Architects and was a vice-president in 1903, the year of his death.

During the course of his life John Scott collected some 12,000 books, many of them very rare volumes. A number of them were historical with no reference to shipbuilding or engineering or science. But his scientific and shipbuilding interests led him to bring together also a large number of works in those fields. This section of the library was retained by the Scott family at the time in 1905 when the rest of the collection was sold. It was lent to the Institution of Naval Architects in 1921 and finally presented to that Institution by the late Mr. R. L. Scott in 1930.

For many years the collection has been kept in a separate room at the Institution, known as the Scott Library. Now, through the labours of Betty M. Cooper, who was librarian to the Institution between 1951 and 1953, this fine catalogue of the collection has been produced. Its compilation has involved Miss Cooper in very many months of such labour as only, perhaps, another librarian can fully appreciate. It has brought her into contact personally or through the post with a variety of people, including many librarians and curators in this and other countries. For many of the books in the collection are rare and it has been necessary to make inquiries from many sources to get information about them such as a good catalogue should offer. For the user of a catalogue needs to have not merely a list of what is contained in a collection, but some guidance as to what the books are about, as to the authority with which the author writes, as to the state of the volume, and as to the special importance, if any, of the work. Catalogues, of course, do nothing to increase knowledge in themselves. But how very much a well-drawn-up catalogue like the one before us can do to facilitate access to knowledge and to make known to the ignorant what sources of knowledge are available ! In the production of this catalogue the printers as well as the compiler should come in for a share of praise. It is a model of the way in which a good catalogue should be set out and printed.

GEARING.—A number of articles on gears and gearing, by Dr. H. Walker, which have appeared in the news letters of John Holroyd and Co., Ltd., of Milnrow, have now been reprinted in booklet form.

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

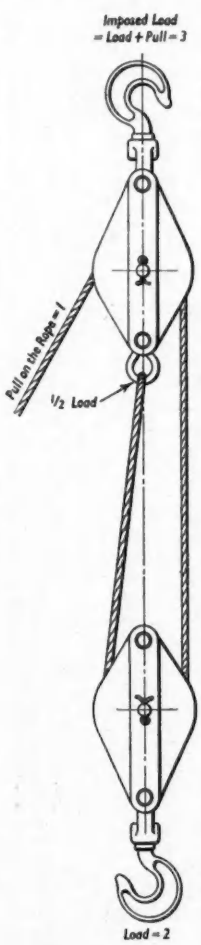
SAFE WORKING LOADS OF ROPE BLOCKS

SIR,—After a rather lengthy correspondence with various members of the B.S.I. committees in connection with the recommended Safe Working Loads of Rope Blocks as given in the B.S. Specification 1839 : 1952, I now consider it advisable to call attention to the unsatisfactory information relating to the loads as given in Table II of that specification, which is causing a great amount of controversy and misunderstanding to all users of this type of tackle.

Safe Working Load and Proof Load of London Pattern Pulley Blocks

Nominal size of block	Circumference of rope	Safe working load of block			Proof load of block		
		One sheave or snatch	Two sheave	Three sheave	One sheave or snatch	Two sheave	Three sheave
Inches	Inches	Cwt	Cwt	Cwt	Cwt	Cwt	Cwt
2½	1¼	½	2	3	3	4	6
3½	1¾	2	5	8	8	10	16
4	2	3	8	12	12	16	24
4½	2¼	4½	12	18	18	24	36
5	2½	7	18	28	28	36	56
6	3¼	10½	28	42	42	56	84
7	4	13½	36	54	54	72	108
8	4½	18	48	72	72	96	144

I find that a number of lifting tackle manufacturers in their catalogues give a list of the test or working loads for London Pattern rope blocks, and each states that a pair of one-and-one-sheave blocks carries twice the load of a one sheave. A confirmation of this simple fact was obtained from a member of the B.S.I. If we now refer to Table II of the B.S. Specification 1839 : 1952 (reprinted herewith) we find that the safe working load of, say, a 4in by 2in one-sheave block is 3 cwt, but the table does not impart any exact information as to what the S.W.L. of a pair of one-and-one-sheave blocks should be, particularly noting that the S.W.L. of a two sheave is given as 8 cwt. If we assume that this relates to a two-and-two-sheave combination, the load on the rope or safe working load per sheave is 2 cwt. As this matter concerns the all-important Factory Act Regulation (i.e. that the S.W.L. must be stamped on all such tackle) I asked what this should be and was informed by the B.S.I. that this should be 3 cwt, the same as the one sheave, and that a one-sheave block, when used in a combination of one and two sheaves, carries a S.W.L. of 6 cwt—again 2 cwt per sheave.



To state that a pair of one-and-one-sheave blocks should not lift any more than a one sheave is, of course, in opposition to the usual trade practice and normal simple mechanical principles. When a bottom block is fitted to any lifting appliance, this must double the capacity of single-sheave lift, as the load is now carried a on two ropes instead of one. A further mistake is to be found in paragraph 16, page 10, where the proof load of the becket of a one-and-one-sheave block is given as one-third of the proof load applied to the block. From my correspondence, I find that the admitted mistake has been made by assuming that the imposed load (due to the pull on the rope) on the top block of a one-and-one-sheave is the S.W.L. of the block, whereas the S.W.L. is the load lifted on the bottom block and is only two-thirds of this, which then makes the S.W.L. on the becket one-half the actual working load on the block (see diagram).

In a supposedly frictionless system of this type of tackle, it follows without question that the load on the becket is in inverse proportion to the number of falls of rope upon which the load is carried and that the capacity of the blocks is in direct proportion to the number of falls of rope.

Furthermore, it is now agreed amongst many manufacturers that the only simple and " foolproof " way to mark the S.W.L. on a block is to stamp the " S.W.L. per sheave " on each block which has been designed for a suitable size rope. For example, 4in by 2in blocks would all be stamped " 2 cwt per sheave," then the S.W.L. of any combination can be found by counting the total number of sheaves and multiplying by 2 cwt. In my opinion, Table II is misleading and incomplete and requires amending to show all the correct data for each separate combination, which would then coincide with the above method of marking.

G. H. BOOT

Birmingham, 17.

Airfield Runways

THE design and construction of airfield runways was discussed at the Institution of Civil Engineers last Tuesday, when a paper by J. A. Skinner and F. R. Martin entitled " Some Considerations of Airfield Pavement Design " was presented. The increasing complexity of construction, due to increasing weights and tyre pressures, was outlined in the paper. Several possible improvements which might be introduced into present-day work were suggested by the authors, for both rigid and flexible construction. In their opinion the C.B.R. method was probably the only system which had been reasonably well used and proved in practice, but a new basis of design for flexible pavements should be devised. Such a method, they stated, should be based on an *in situ* ground test and should cover the determination of the stability required for the various layers including the surfacing. Investigation was also required, the authors considered, into the development of less orthodox methods of construction, such as the use of continuous layers of rolled dry lean concrete and stabilised soil. But perhaps the greatest advance, they considered, would come from the possibilities of prestressed concrete, which could give a virtually jointless slab with a sure flexible strength, practically unaffected by climatic variations. They pointed out that the principal difficulty in this form of construction was that of ensuring correct distribution of stress throughout the slab and overcoming the subgrade restraint, but a solution might lie in supporting the pavement off the ground during the process of stressing. A 6in pavement, evenly stressed with a few hundred pounds per square inch, could be enormously strong, they maintained, and well able to withstand the heaviest loads likely for many years to come.

The Engineers' Tide

By A. C. M. SIGSWORTH, M.Eng.

The author of this article recently took a course at the Post-Graduate School of Applied Mechanics at Sheffield University. The article amounts to a statement of his reasons for doing so, his convictions that post-graduate schools of this kind are becoming essential for the training of engineers, and his belief that technologically trained men should play a greater part in guiding the destinies of firms.

"There is a tide in the affairs of men, which, taken at the flood, leads on to fortune; omitted, all the voyage of their life is bound in shallows and in miseries. On such a full sea are we now afloat; and we must take the current when it serves, or lose our ventures."—*Brutus.*

IT is said that Great Britain has lost her position as the workshop of the world and that our salvation lies in our becoming the idea shop of the world. It is essential for our exports to have a high brain content, and to this end research provides a means. In the application of research, however, we have in the past been handicapped in two ways—first, the refusal of much of industry to look in this direction, and secondly, the shortage of staff suitably trained to develop those products which we are to put in the window of our new idea shop.

The recent leading article[1] reviewing the Manchester University book *Industry and Science*, and the subsequent correspondence, paints the present position in such drab colours that even the most powerfully rose-coloured spectacles cannot persuade us that the future is bright. Most of the findings of the Manchester investigation are merely echoes of much that has appeared in print of late, and will come as no surprise to the many engineers who sweat in the stokehold of the industrial ship, nor even to those few engineers who have managed (they alone know how !) to reach the captain's bridge and see even more clearly just what is in front of us.

However, even the greatest desert has its oasis, and the present situation was foreseen some years ago when some preparation was made to meet it by the establishment at several of our universities of post-graduate schools to attempt to relieve the acute shortage of men capable of translating the syntax of science into the vernacular of industry. For the success of these schools they must show that they can help both industry and the individual. The number of men who have yet attended is still relatively small, but it is desirable to take stock to see how far they are fulfilling their aims and the views of someone who went from industry to such a school may be of interest.

First, as the poor are always with us, mainly because the economists are always here as well, so the industrial problem can best be tackled by placing technologists in senior positions in industrial concerns. This would remove much of the lethargy overnight. But as there would not be sufficient suitable technologists to go round and as man's inhumanity to man (and especially to engineers) is well known, we cannot hope to accomplish this desirable aim in the near future. Hence, there is a need for constant preaching and continual persuasion to convince industry of the folly of her ways. It will be futile for the orthodox scientist to preach to the orthodox industrialist, as C. N. Kington[2] has pointed out, "There is a burning need for a new class of scientist able to bridge the gap by reason of academic ability compounded with an understanding of works mentality and problems." To help train this new class is the principal aim of the post-graduate schools.

There are many who are not convinced that science can help them very much at all, but a knowledge of research technique and modern instrumentation can benefit the most unlikely industry. For instance, a considerable activity has developed in recent years in the building of excavating machinery; it is a comparatively young industry and competition, especially from the U.S.A., is very keen, but there are undoubtedly great opportunities. Development of these machines has traditionally taken place by building one, starting it to work on a suitable site and then sitting on a ready pile of spares to watch it work. Although each manufacturer has to some extent enjoyed sitting on his competitors' pile of spares as well, most of the available knowledge of these machines has been accumulated by trial and error methods by each manufacturer. There can be no doubt that these methods have had considerable success, but much of the design of these machines is done "as through a glass darkly," being greatly influenced by opinions, prejudices and an often unyielding regard for past practice. There is a certain amount of justification for this; you never shift the same load of muck twice, operating techniques are as numerous as operators and as varied as job requirements. It is known that if abused a machine can destroy itself, although there is some disagreement as to what is abuse. From the research angle the difficulty of approximating to an operating cycle must be faced, and, of course, when a test is completed there is still only personal opinion available to grade the relative severity of the test. To establish any standard of severity would be a somewhat dubious proposition and would probably be expensive.

However, a recent paper[3] shows that a great deal can be learned by suitable research technique for devising tests at a variety of loads below the maximum. Less damage may result from occasional peak loads than from frequent smaller loads, and, in any case, a great deal can be learned by subjecting certain vital parts to tests at high load. Stress determinations made on an actual part under service conditions by the use of electric resistance strain gauges can throw a great deal of light on its suitability for the duty imposed on it. In the paper mentioned, these gauges and quite simple apparatus were used to investigate the characteristics of an excavator power plant; the torque required for such operations as simultaneous hoisting, swinging and crowding was determined directly at the transmission shaft. Loading frequency is a great problem in excavator design, but research indicates that it may not be so open to anybody's guess as was thought, since a very large bucket digging virgin earth was found to be subject to a consistent loading pattern with uniform digging and operating conditions. Some early tests indicate that it is possible to analyse better the requirements of brakes and duties on excavators which are subjected to a particularly arduous service. These examples are cited to show how research can help an industry which does not seem, at first sight, to have a product or conditions amenable to some conceptions of research.

A somewhat similar problem occurs in the design of mechanical power presses, as frequency and magnitude of loading are widely variable, materials of work and die may not be consistent and there is always the chance of the operator feeding two blanks at once. Nevertheless, a photo-elastic investigation of the stresses in a press frame can form the basis of a design in which material is used to the best advantage. One firm sent a student to the Post-Graduate School at Sheffield to undertake such an investigation with a marked degree of success, not only for a particular press frame, but in establishing a technique that will be invaluable in designing any future press frame.

The Manchester investigation revealed that industry is often in some difficulty about where to go for the most appropriate source of knowledge, and here the post-graduate schools can be of immediate assistance to the firm that is far-sighted enough to send a man to one of them. One of their purposes is to acquaint the student with the advanced techniques and concepts which are of major importance, but descriptions of which are scattered throughout the vast numbers of technical publications and actual practical experience of which would be very difficult to secure in any other place.

There is a great deal to be gained from sponsored research, but those who always follow the current fashion look through their eye-glasses and see a mighty mountain of objections to it instead of the irritating pimple which always attacks certain people when any change is mentioned and becomes particularly virulent if it should be a change for the better. As Professor Ewen M'Ewen wrote in THE ENGINEER, "It is time the possibilities of sponsored research were re-examined without the hindrance of cant and prejudice." To some extent the post-graduate schools can help here, for it is possible, in Sheffield at any rate, for a firm to send a student to investigate some particular problem on their behalf while enjoying all the help which the staff and the university can give.

A fear often expressed is that co-operative research may mean the loss of trade secrets. There is a great deal of myth attached to the value of many of these trade secrets, any advantage is one of time only, for many firms commence new designs by examining the comparable products of their competitors and it depends largely on the critical faculty of the examiner whether the new design incorporates the desirable or (as it sometimes turns out) the undesirable features of the competitors' manufacture. The quality of the technical staff and the value placed upon them are the factors which will determine whether a firm will retain (or obtain) a technical lead over its competitors. Where a technical staff, however good, is employed merely to impress visitors or to give some substance to the sales publicity, progress is slow and hard won. Where the technical staff is valued for its own sake, the importance of technical knowledge is also appreciated and there are many cases where a firm has been known to suffer considerable inconvenience to send a man to one of the courses, justifiably believing that the new ideas and different viewpoint with which he returns is more than a just compensation.

There are many considerations for the individual as well. Engineers working in industry are usually up-to-date on current practice in their own field, but when it comes to looking in someone else's field for ideas they may use in their own, they frequently need some outside help. To appreciate the

considerable advances that have been made in every branch of technology, some specialist knowledge is required which the engineer has not always been able to obtain in the course of his duties. The value of teaching this sort of specialist knowledge at undergraduate level is beset by many difficulties. There is the fact of an already overloaded syllabus to consider and perhaps most of all there is the nature of the engineering profession, in which a man setting out to be, say, a machine tool designer, may end up in charge of a cement factory, whilst your budding hydraulics engineer may find himself constructing roads. Because of this, it is advisable for acquisition of specialised knowledge to be delayed until the young engineer has had some years in industry and has some idea of that branch of engineering to which he will likely devote his life. It also helps to ensure that when the engineer is in a position to use this specialised knowledge, he obtains it in the most up-to-date form available. This situation is met largely by the post-graduate schools, which give opportunity, guidance and encouragement to study the latest methods in their own and related fields, to suitably qualified engineers who have had some years of industrial experience.

One question which always looms largely is how to get the time off to attend such a course, for, as has been remarked, some employers are reluctant to release a man for a full academic year, although in the case of Sheffield, shorter courses can be arranged. The engineer also has to remember that a big factor in promotion is being in the right place at the right time—he may have to weigh carefully the possible improvement in his prospects consequent upon his enhanced knowledge, against the loss of any experience he might have obtained had he not been away on such a course. The general concensus of opinion amongst one group of students was that the greatest benefit would definitely be obtained from attending the full session. It is possible to use the work done on such a course to obtain a master's degree, whilst non-graduates are eligible for the award of a Diploma. A student obtaining one of these has a great personal satisfaction in the course in addition to any advantage he may bring his employers.

Some employers are very enthusiastic about post-graduate courses, and when releasing a suitable man give him leave of absence with full pay. As the man may study a problem immediately connected with his work, these employers can reap an immediate advantage in the improvement in their product on the man's return. Not all employers have an eye to the future and one finds students who have come along "under their own steam." One student in Sheffield, for instance, threw up his £750 a year job to attend, although his employer was unable to keep his post open because its vital nature demanded a replacement as quickly as possible. It is on record that such a student who went on the course in "Thermodynamics and Related Studies" at Birmingham, doubled his salary upon returning to industry. A student intending to do anything like this is well advised to consult the university authorities beforehand, as there are useful grants available to suitable candidates.

A graduate is not in industry very long before he realises that many of his superiors have a passing acquaintance with formulas such as πR^2 and a grave suspicion of any theory that is not mentioned in whatever copy of *Old Moore's Almanac* they happen to use, when by some mis-chance πR^2 cannot be applied to the problem in hand. Undoubtedly, rules of thumb and the shrewd glance of "the engineer's eye" have their place and served us well in the more leisurely days that are past. Such methods are being buried in the snow of to-day's economic blizzard, but many who remember the golden days of the past are sceptical and sometimes hostile to modern methods. Consequently, your young engineer, who is already having to fight uphill against this sort of attitude, may be pardoned for wondering whether advanced knowledge is capable of having any practical application. At least he is aware after a few years in industry that theories that are difficult to comprehend because they are presented in a form that is difficult to digest, stand little chance of being converted to a practical reality. This was one fear that most of the students shared when deciding to take a post-graduate course. However, there is a keen appreciation of this problem and the lecture courses are designed to have a ready application to practical problems and the needs of the practising engineer are constantly in mind.

An example of this is the lecture course on "Gearing" at the Post-Graduate School of Applied Mechanics in Sheffield. Undergraduate teaching on this subject leaves the student with the impression that it is associated with some obscure form of geometry, and the industrial gearing experience of some of us serves to confirm us in the belief that the whole subject of gear design, if not one of profound mystery, is at least one of considerable complication, and the most successful gears are designed by those who keep their fingers crossed. Of course, many factors associated with gear design are either empirical or have to be treated with some discretion, and this may be one reason for the difficulty. However, it must be recognised that someone has to design gears by some means or other until the theorists have sorted things out. Sheffield, by concentrating on essentials, dealing with difficulties as they arise in the way that industry must deal with them, shows the student, by precept and example, how to cope with almost any gear problem he is likely to meet.

Laboratory courses are particularly successful when they demonstrate experiments that can be applied to practical problems with a minimum of apparatus and are capable of quickly producing results to the order of accuracy required for industrial purposes. If the apparatus is of a simple construction that can be readily made up in the works engineering department with a minimum of delay and expense, then they are so much more attractive. Typical apparatus of this sort, constructed by students and examples of the kind of problem that can be solved, were given in a recent article.[4]

Not all practical problems need laboratory tests for their solution, but what they do need is a better atmosphere than exists in many works, the sort of guidance that a university department can give and a relief from the day-to-day affairs of industry, for, in the words of Ecclesiasticus, "The wisdom of a learned man cometh by the opportunity of leisure: and he that hath little business shall become wise."

A student at Sheffield had noticed that it was possible to run roller chains at speeds faster than that determined by existing formulas for limiting speeds, which are based on a conception of limiting kinetic energy of impact between the roller chain and sprocket. The conditions at impact are so involved that even if the kinetic energy theory is rejected, the effort and time required to find a satisfactory alternative is such that someone coming across the problem in industrial surroundings would probably pass it by. However, after discussion with various members of the staff, a new approach to the problem was evolved, namely, the limiting surface stress between the roller and sprocket at impact. This can be related to surface stress values given in current British Standards for gears and is capable of practical application.

The greatest incentive for the individual engineer is contained in the fact which has emerged not only from the Manchester investigation, but which has been continually before us of late, i.e. the need for positions of senior responsibility to be occupied by men with a full technological training. Hard-pressed competition will gradually force this point home and the technologist will come into his own, because at the moment many firms are not in a position to recognise an idea, let alone bring it to fruition. Technological training is of the greatest importance, not only in recognising an idea, but in seeing ahead both the opportunities and the difficulties likely to be encountered in exploiting the idea. This is where it is important for the individual to obtain the widest range of technological training that he can, because only an engineer so equipped can hope to succeed in the days ahead.

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[2] Correspondence to THE ENGINEER, April 9, 1954.
[3] Davidson and Meier: "Research on the Performance of Power Cranes and Shovels," S.A.E., 1954.
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Tube Stock for London Transport

WE are informed that London Transport has placed orders for three prototype tube trains of a new design. To enable full operating and maintenance experience to be gained before the placing of large production orders, an order for a complete seven-car train has been placed with each of the three manufacturers, the Birmingham Railway Carriage and Wagon Company, Ltd., the Gloucester Railway Carriage and Wagon Company, Ltd., and the Metropolitan-Cammell Railway Carriage and Wagon Company, Ltd. Each of the three prototype trains will be made up of a three-car and a four-car unit, either of which will be capable of operating independently in service. The general design evolved for the new stock, whilst following closely the 1938/1949 vehicle layout, has important differences in regard to construction, equipment, seating arrangements and lighting.

The main points of difference between the new stock and the 1938 class will be in the use of unpainted aluminium alloy for exterior panelling, bogies of entirely new design incorporating a system of rubber-in-shear springing in place of conventional steel springing and, for the first time in tube stock, fluorescent lighting.

The decision to use light alloys for the body panels follows the wholly favourable experience with "R" stock (surface line) cars, and its use will effect a saving in weight of about 1 ton per car. The underframes will be of steel. It is pointed out that the stock built in 1938 is already of light steel construction, which allows the traction equipment to be placed in the restricted space under the floor of the car. It was felt that the additional saving in weight to be gained by the use of light alloys for the underframes (always providing a design could be evolved which did not materially reduce the already restricted space available) would not be sufficient to justify the increased primary cost. So far as body frames are concerned, the question of whether or not to use light alloys will be resolved at a later date with the individual builders.

It will be recalled that rubber suspension for bogies was developed at the instigation of London Transport's late chief mechanical engineer—Mr. W. S. Graff-Baker—and one car on the District Line has been running since October, 1947, with a rubber bolster suspension, and since March, 1953, with both rubber bolster and rubber axlebox suspension. To obtain experience with this system of springing on tube stock motor

bogies, two bogies have been specially constructed for trial purposes. In the new cars the opportunity is being taken to make minor technical improvements to achieve not only a reduction in capital and maintenance costs, but also an improved standard of reliability. In particular, the motor characteristics have been altered to improve the efficiency of operation, so reducing energy consumption without detriment to the service. The new stock will be equipped at the outer ends with a simple mechanical coupler, for emergency use only, with no through electrical connections.

Some simplification of the pneumatic brake equipment, to improve reliability and ease maintenance, has been found possible, as well as an improvement in protection of the pneumatic equipment against freezing. There has been a further development of compensated and retractable shoe gear (already in use on post-war rolling stock) whereby laminated plywood shoebeams are used for the mounting of positive shoes and tripcock, and also for operating the compensating mechanism of the frame-mounted negative shoe gear. A detachable lever, accessible through a floor-trap, enables both positive and negative shoes to be retracted simultaneously in emergency.

For the first time fluorescent lighting is to be used on tube cars and a double row of 5ft fluorescent lamps will be closely spaced in a specially-designed fitting along the centre of the car at ceiling level.

Delivery of the prototype trains is expected in the spring of 1956 and they will be run on a number of the tube lines to obtain experience of the different kinds of traffic and conditions of running.

Spectrometer for Noise and Vibration Analysis

A ONE-THIRD octave spectrometer designed for analysing a spectrum from 10 c/s to 100 kc/s is being made by Salford Electrical Instruments, Ltd., Magnet House, Kingsway, London, W.C.2. It is intended mainly for the study of complex noise phenomena, but it can also be used for various applications involving frequency analysis—for example, the production testing of transformers and amplifiers and the analysis of vibration in turbine blades and rotating shafts. A typical application is illustrated in Fig. 1, which shows the spectrometer being used to analyse the torsional vibration of a marine diesel engine shaft.

The apparatus consists of two main units mounted on a wheeled trolley (Fig. 1). The upper unit consists of the spectrometer with its cathode-ray tube display and controls mounted in a splashproof case. The lower unit, mounted in a separate splashproof case, consists of a power pack. These units weigh 200 lb and 66½ lb, respectively, and both cases are fitted with carrying handles and runners to facilitate handling.

In operation the equipment is set up with a suitable pick-up head applied to a convenient part of the source of the vibration that is being studied. One of three available frequency ranges (10 c/s to 6·4 kc/s, 30 c/s to 10 kc/s or 320 c/s to 100 kc/s) is selected on the spectrometer display unit. Analysis of the applied waveform is then effected within the spectrometer, as described below, and the component frequencies of the waveform appear on the cathode-ray tube as a series of vertical lines. The height of each line is proportional to the amplitude of that particular frequency component, and the frequencies are determined with the help of a series of spots which are derived from a mechanical time-base and form the horizontal scale of the display. Each spot represents a certain frequency and a key giving the appropriate frequency is mounted on a panel just below the cathode-ray tube, as can be seen in Fig. 2. Provision is made for the fitting of a camera to photograph the display, if required.

A block diagram of the spectrometer is reproduced in Fig. 3. The input circuit consists of a cathode follower which is coupled to a cascade amplifier, with a substantially flat response between 10 c/s and 100 kc/s, and to the grid of the overload indicator circuit. Negative feedback is used in the amplifier output stage which consists of a cathode follower. This output is applied to thirty-eight filters in parallel, which provide the frequency-discriminating characteristic of the spectrometer. With the exception of the 10 c/s, 20 c/s and 30 c/s filters, the spacing of the remainder is logarithmic with three filters per octave; and the circuits of all the filters except the 10 c/s are identical. The filters are designed to have a cross-over frequency of 50 per cent above and below the mid-band frequency and the response of each filter at the next mid-band frequency does not exceed 20 per cent.

The output of each filter is passed, via a "range switch," either to a crystal diode or directly to a "filters out" switch. The output from the crystal diode feeds a time constant circuit of either one second in the long-time constant position or 0·1 second in the short-time constant position. Thence the d.c. output is passed to the appropriate segment of the filter output selector which is a rotary switch having a moving arm mechanically ganged to the time base. Accordingly, the moving arm output consists of a number of d.c. pulses, the height of each pulse being proportional to the amplitude of a particular component frequency in the

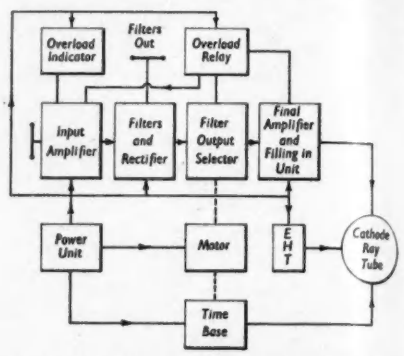


Fig. 3—Block diagram of spectrometer for vibration analysis

waveform under examination. This moving arm output feeds the output amplifier and the grid of the overload trip valve. The output amplifier feeds a final amplifier, via the "filling-in" circuit, in which a high-frequency component is introduced, to give a vertical-line display instead of displaced spots. The output valve is directly coupled to the "Y"-plates of the cathode-ray tube.

An overload relay and indicators are fitted (Figs. 2 and 3). The overload relay disconnects the input to the output amplifier, should a certain pre-set signal level be reached; while the overload indicator shows whether a positive or negative peak is the cause of the overloading, and remains in operation until the input signal is reduced.

The main controls of the display unit can be seen in Fig. 2. The range switch selects the output from twenty-six filters at a time to bring into operation the following ranges: (1) 10 c/s to 6·4 kc/s; (2) 30 c/s to 10 kc/s; (3) 320 c/s to 100 kc/s, and (4) filters out. In position (4) the filters are connected via the "filters out" switch to the "filters out" terminals, so that the output from any individual

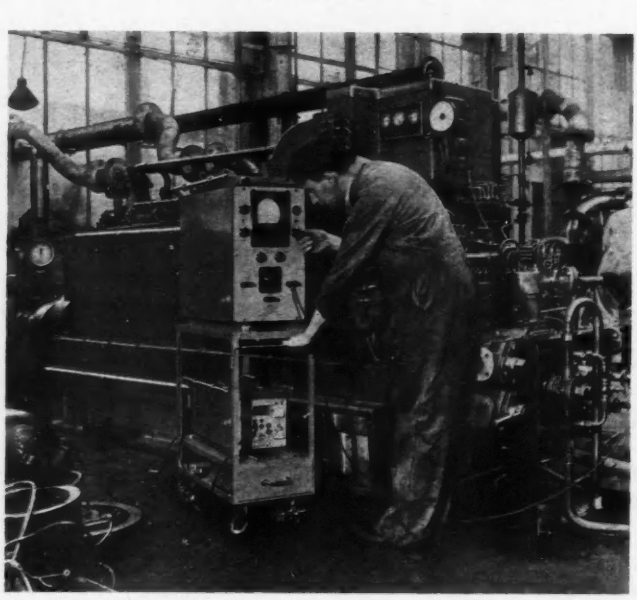


Fig. 1—Spectrometer being used for analysing the torsional vibrations of a marine diesel engine. A typical indication obtained during such a test is shown in Fig. 2

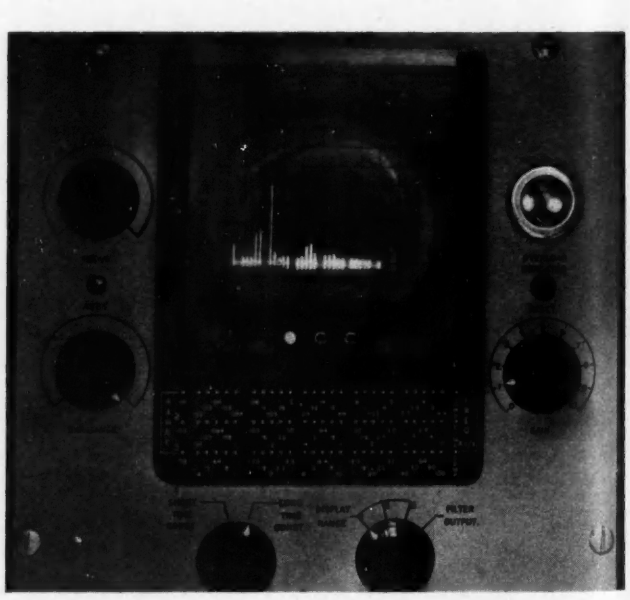


Fig. 2—Torsional vibration on shaft of marine diesel engine at 400 r.p.m. The display shows that the maximum amplitude is at about 80 cycles per second

filter can be obtained while the cathode-ray tube is disconnected. The time-constant switch alters the time constant of the filter rectifier output circuit and hence the duration of the image on the screen. The two time intervals are 0·1 second and 1 second.

The power pack is designed for input voltage ranges of 70V to 120V or 200V to 250V, 50/60 c/s a.c. An auto-transformer arrangement is used to supply the 230V a.c. required for the motor, which drives the time base mechanism. Three separate high tension output supplies are provided by the power unit and one of them is stabilised. All controls are accessible on the front panel—" on/off " switches, fuses, stabiliser voltage control, and voltage selector. The power unit is fitted with micro-switches which make only when the connecting plug to the main unit is in position. If this is not in position the unit cannot be switched on.

In Fig. 1 we show the equipment set up for measuring torsional vibration in the shaft of a marine diesel engine at the works of Crossley Brothers, Ltd., Openshaw. An electromagnetic pick-up, mounted on the end of the shaft, is connected directly to the spectrometer. A typical display obtained with the shaft rotating at 400 r.p.m. is shown in Fig. 2. The lowest range 10 c/s to 6·4 kc/s, was used and the left-hand indicator lamp (immediately below the screen, Fig. 2) is, therefore, illuminated.

The display shows that at 400 r.p.m. the amplitude of the vibration was greatest at frequencies around 80 c/s. When a similar test was made at 500 r.p.m. the amplitude of the vibration was found to be greatest at a frequency of 64 c/s.

Fulmer Research Institute

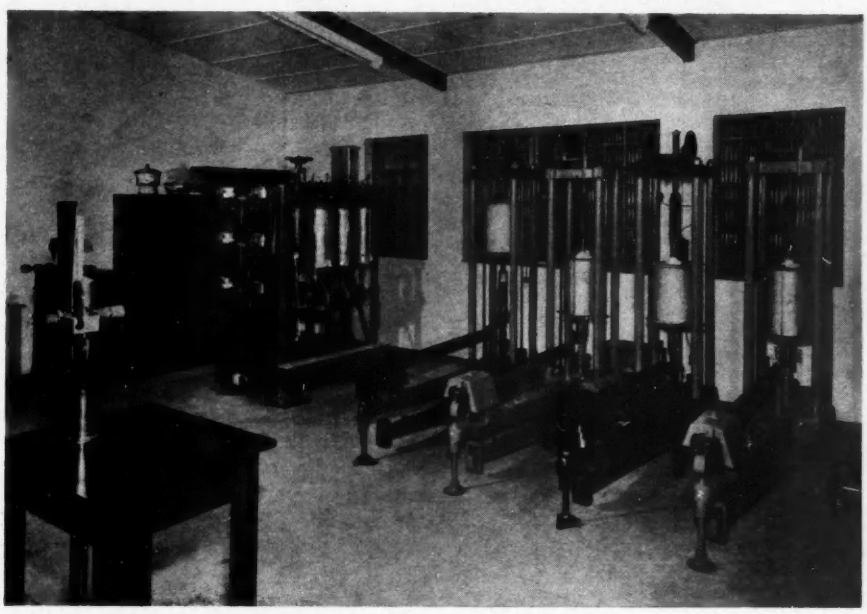
TUESDAY of last week was open day at the Fulmer Research Institute, Stoke Poges, Bucks, and the Duke of Edinburgh was amongst a large number of distinguished guests at a luncheon which preceded a tour of the laboratories.

The Fulmer Research Institute which was founded in 1946 receives no grants from public funds, its income depending entirely on research work undertaken for industrial and Government sponsors. The work of the Institute lies mainly but not exclusively in the metallurgical sphere.

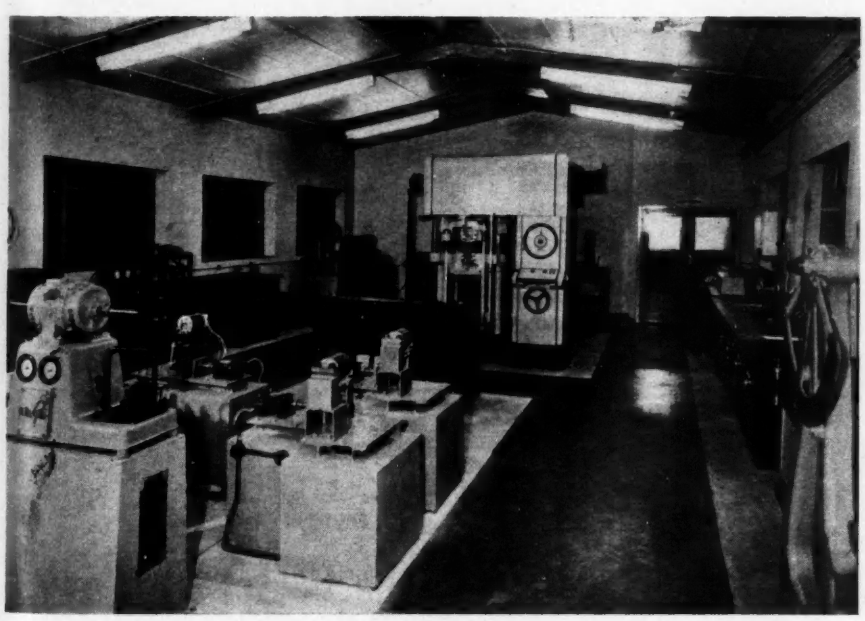
On the occasion of the open day this year the Institute was able to open its new engineering laboratory. In our first illustration of the laboratory can be seen some of the tensile creep machines, the group of four installations being used for high-precision work. At the far end of our other illustration is a 50-ton tensile testing machine and in the foreground are a group of fatigue testing machines which include high temperature bend fatigue machines and a Haigh fatigue testing machine, also adapted for high temperatures. Other equipment provides for tensile testing at low, normal and high temperatures, impact fatigue and hardness testing, and for the investigating of brittle-ductile transition temperatures on metals. The tensile and compression creep testing machines are installed in a temperature controlled room.

One of the more important commitments of the Institute is its work on the extraction of aluminium by a catalytic distillation process. From theoretical considerations Dr. Gross deduced the existence of a monochloride of aluminium and subsequently went on to prove that pure aluminium could be produced by alternating the formation on heating and decomposition of this compound on cooling. The commercial process depends on the reversible reaction between aluminium trichloride and any aluminium bearing material to form volatile aluminium monochloride, which subsequently decomposes to yield aluminium and aluminium trichloride. Thus in an atmosphere of $AlCl_3$ (which, subliming at 180 deg. Cent., can metallurgically be considered a gas) aluminium behaves like a volatile metal and can therefore be purified or extracted from alloys by distillation, other constituents being practically unaffected. Extraction of aluminium of high purity from alloys produced by direct thermal reduction in an arc furnace is the most important application of the process which may also be used to purify scrap or aluminium of commercial purity.

The features of the process which are claimed to make commercial operation an extremely attractive prospect are : its intrinsic simplicity ; costly chemical processes for the purification of bauxite are eliminated ; recirculation of aluminium trichloride makes continuous operation feasible, and operating costs are likely to be no higher than in the present electrolytic method. The cost of materials used or lost in the process should be substantially reduced compared with the present method. Further laboratory and development work is continuing, particularly with a view to encouraging commercial applications.



Controlled temperature creep testing room in the new laboratory



Some fatigue testing and impact testing machines (foreground) and 50-ton tensile machine

Titanium.—Similar methods are now being applied to the preparation of pure titanium (and other metals) since present methods of production are unlikely to yield the quantities at a price which will make extensive application of this valuable structural metal possible. Early experimental results obtained by Dr. Gross and his team are encouraging and some titanium has been produced. Much work remains to be done and laboratory investigations are continuing on the processes and the fundamental thermodynamic properties involved.

275kV Sealing Ends at Brighton " B " Power Station.—The British Electricity Authority has recently installed 275kV sealing ends instead of the previously existing 132kV sealing ends which terminate the outgoing 132kV oil-filled cables associated with generators Nos. 1 and 2 at Brighton " B " power station. This change is designed to alleviate the effects of salt deposits on the porcelain insulators which are sited within 100 yards of the sea, at the foot of a terminal tower whereby the circuits are carried by overhead line across Shoreham Harbour. On the original installation, despite protective barriers against direct spray, the accumulation of salt deposits on the porcelain insulators caused flashovers during bad weather. To avoid excavating and re-routing some 100 yards of the existing 132kV cables, the additional length of core required to make the 275kV sealing ends, was obtained by jointing a short length to the ends of the six single-core cables. The resulting straight joints were accommodated inside the new sealing ends, which were supplied and installed by Pirelli General Cable Works, Ltd., who also carried out the previous installation.

Transatlantic Telephone Cable*

By M. J. KELLY, Sir GORDON RADLEY, G. W. GILMAN, and R. J. HALSEY†

A general description is given of the cable system which will provide thirty-five transatlantic telephone circuits linking the United Kingdom, Canada and the United States. The main link will consist of two cables, each nearly 2000 nautical miles long. Each cable will contain fifty-two submerged repeaters laid at depths of up to 2000 fathoms, whereas no existing cable is more than about 200 nautical miles long or contains more than seven repeaters. The scheme is being engineered jointly by the American Telephone and Telegraph Company, Ltd., and the British Post Office and it is due for completion in 1956.

In December, 1953, plans were announced by the American Telephone and Telegraph Company, the British Post Office and the Canadian Overseas Telecommunication Corporation for the laying of the first transatlantic telephone cable system. The system will provide thirty-five high-grade telephone circuits between the United Kingdom, Canada and the United States, and plans contemplate commercial operation at the end of 1956.

In scope the project far exceeds anything that has been attempted hitherto ; the two cables on the main crossing will each be nearly 2000 nautical miles‡ (n.m.) long and each will contain fifty-two submerged repeaters, laid at depths of up to 2000 fathoms, whereas at the present the longest submarine telephone cable is about 300 n.m. long and no cable contains more than seven repeaters. The American Telephone and Telegraph Company and the British Post Office have joint engineering responsibility for the project, which is the outcome of studies and experiments started many years ago. It will represent a major step forward in the evolution of the transatlantic telephone service which began in 1927 with the establishment of one long-wave radio circuit between London and New York.

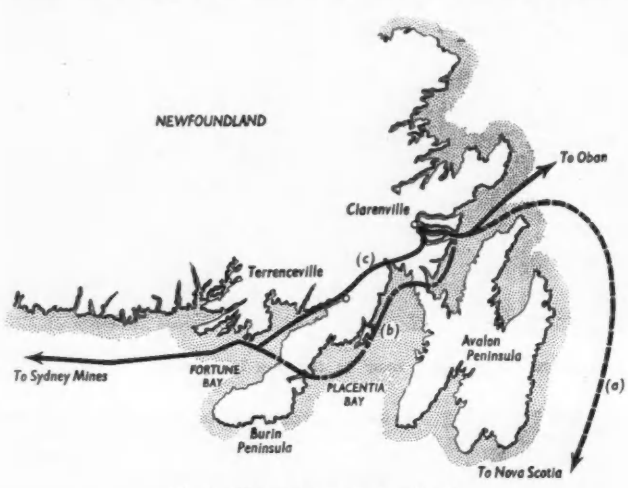


Fig. 1—The route in Newfoundland

Route.—A map of the route in Newfoundland is shown in Fig. 1. The route between Clarenville in Newfoundland and Oban in Scotland has been chosen so as to be well clear of existing telegraph cables, which lie to the south, and also to avoid known " holes " in the ocean bed. Selection of a landing site in Newfoundland was determined by the following considerations :

(*a*) The cables remain in deep water until they enter the north-western arm of Random Sound where damage is not to be anticipated from grounding icebergs.

(*b*) There is no crossing over other cables.

(*c*) Clarenville provides reasonable amenities for the staff who will have to maintain equipment associated with the cables to Scotland and Nova Scotia.

Both the cables between Clarenville and Oban will be approximately 1950 n.m. long and each will be equipped with fifty-two repeaters. The greatest depth at which a repeater will lie will be approximately 2300 fathoms (2·6 statute miles), but most will be at depths between 1200 and 2000 fathoms.

Three alternative routes connecting Clarenville with Nova Scotia were considered ; none was particularly attractive from an engineering standpoint. They were :

(*a*) To leave Clarenville generally in an easterly direction and to lay the cable in a wide sweep round the Avalon Peninsula and in deep water to the south of the Newfoundland Banks.

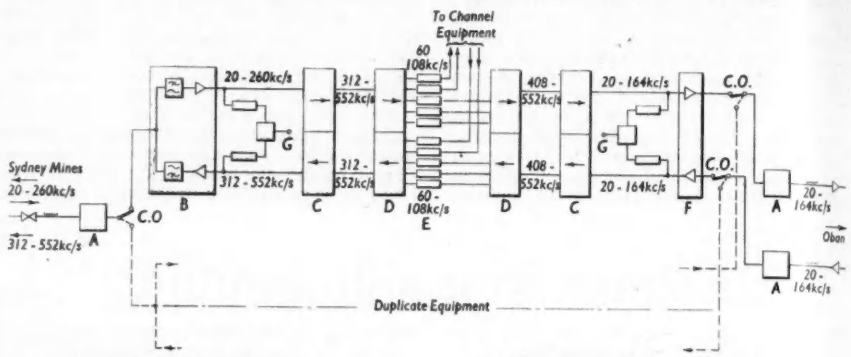
(*b*) To leave Clarenville generally in a southerly direction, cross the Avalon Isthmus (about 5 miles wide) into Placentia Bay, cross the Burin Peninsula (about 10 miles wide) into Fortune Bay and thence in water of moderate depth to Sydney Mines.

(*c*) To lay the cable overland to Terrenceville at the head of Fortune Bay, thence picking up the same inshore route as in (*b*) above.

The first of these would have involved a cable 600 n.m. long crossing a number of existing telegraph cables; the second, while avoiding the main fishing grounds and other cables, would have necessitated landings at four intermediate points. Therefore, after an on-site investigation, the last alternative was chosen. This section thus falls into two parts : to the east about 62 statute miles overland and to the west about 274 n.m. in coastal waters at depths up to about 250 fathoms. The single cable will be equipped with sixteen repeaters, two of which will be on land.

Circuit Capacity.—The cables between Clarenville and Oban will have transmission frequency bands extending from 20 kc/s to 164 kc/s and will provide capacity for thirty-six carrier telephone circuits, with channels at 4 kc/s spacing. The capacity of the cable between Clarenville and Sydney Mines will be somewhat greater, because it is planned to transmit the frequency band 20-260 kc/s from Sydney Mines to Clarenville and the frequency band 312-552 kc/s in the reverse direction. The cable will therefore provide sixty carrier telephone circuits with channels spaced 4 kc/s apart. One of the two twelve-channel groups in each direction, not employed for transatlantic service, will be used to provide twelve circuits for " local " telephone services between Newfoundland and the rest of Canada ; the other will be held spare for the present.

The junction point between the east and west parts of the system at Clarenville will be the group distribution frame. The transatlantic channels in both parts will appear on this frame as primary groups in the frequency range 60-108 kc/s. From the frame, connection will also be made to the local and spare groups. Equipment to bring each of the twelve channels in any one transatlantic group down to audio frequency will be installed, but not normally connected. The availability of such equipment is desirable, in order to enable impairments affecting only one or two channels to be localised to one part of the system. Fig. 2 is a schematic of the arrangements at Clarenville ; the arrangements will be generally similar at Oban and Sydney Mines.



A—Cable terminating equipment.
B—Terminal filters and amplifiers.
C—Terminal translating equipment.
D—Group translating equipment.
E—Through-group filters.
F—Terminal amplifiers.
G—Maintenance circuits.
C.O.—Change-over switch to duplicate equipment.
At Oban and Sydney Mines the schematics are complementary to those of the facing equipments at Clarenville.

Fig. 2—Schematic of the equipment at Clarenville

The traffic operating terminals will be in London, New York and Montreal. Twenty-nine telephone circuits will be put into service between London and New York, and six between London and Montreal. It is planned to split the thirty-sixth telephone circuit at the western end between New York and Montreal and to use it for other purposes.

Telephone and telegraph circuits for maintenance purposes will be provided between Oban and Clarenville in the frequency band below 20 kc/s. Between Clarenville and Sydney Mines the telephone channels will be provided in the " cross-over " frequency band between 260 kc/s and 312 kc/s and the telegraph channels below 20 kc/s in one direction and above 552 kc/s in the other direction.

Overall Performance.—Since the transatlantic circuits will serve to connect two extensive telephone networks on opposite sides of the ocean, including connection to the European continent, which will be reached through London, they are being designed to add as little extra loss and other forms of impairment as possible. For example, it has been agreed that the target for the frequency characteristics of the channels between London and New York, or London and Montreal, should be at least as good as that specified by the C.C.I.F. for a 2500km international circuit. Other objectives for the circuits compare favourably with those specified for long-distance circuits wholly on land.§ For the transatlantic circuits the " via net loss " will be 0·5 db measured at 800 c/s or 1000 c/s between London and New York (or Montreal). With a net loss of this order on circuits which will have a one-way transmission time of about 35 millisec, echo control will be necessary, and a study is being made of the best method of applying this. Terminating circuit pads will add 2 db to the loss at New York and 3·5 db at London for calls between the two cities, but when the transatlantic circuits are extended the pads will be switched out of circuit. Thus the normal attenuation on a London-New York transmission will be 6 db

* Abstract. Paper presented jointly to the Institution of Electrical Engineers and the American Institute of Electrical Engineers, London, November 4, 1954.

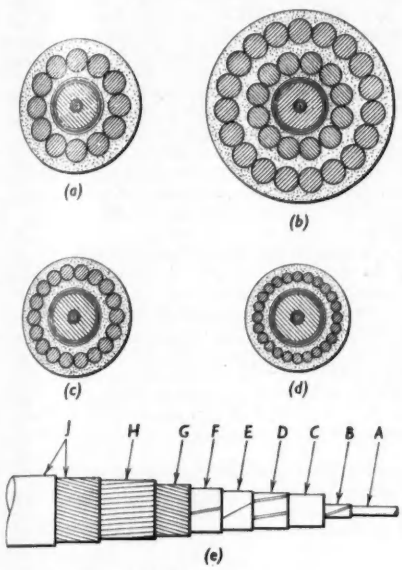
† Dr. Kelly and Mr. Gilman are with Bell Telephone Laboratories. Sir Gordon Radley and Mr. Halsey are with the British Post Office.

‡ One telegraph nautical mile or naut=6087ft=1·150 statute miles.

§ The following have been agreed for the overall circuits London-New York or London-Montreal :
(*a*) Frequency stability better than ±2 c/s.
(*b*) Noise less than 46 db below 1mW, read on the C.C.I.F. (1951) psophometer or 38 dba read on Bell System noise-measuring set with F1A weighting.
(*c*) Minimum crosstalk between any two voice channels not worse than 56 db.

(3·5+0·5+2) or slightly more than the accepted value in regional-centre to regional-centre connections in the United States or Canada. It will be an agreed objective to restrict variations from the normal attenuation to a standard deviation of 1·5 db, and this will put a severe requirement on the inidvidual links which may be difficult to meet. In all respects the requirements for the Sydney Mines-Clarenville-Oban cable sections have to be somewhat more stringent than for the overall circuits.

A pilot tone of approximately 84 kc/s‖ will be injected into each group of twelve channels at a point where the channels appear in the 60–108 kc/s range. Measurements of the received level of the tone will give an indication of the overall attenuation ; later the received tone may be used to control automatically the gain of terminal amplifiers on each group. In addition, 92 kc/s pilot tones, similarly injected, will be transmitted over each section to give an indication of the attenuation of the section. These tones will be blocked from passing from one section to another.



(*a*) Type A ; overall diameter 1·84in.
(*b*) Type AA ; overall diameter 2·68in.
(*c*) Type B ; overall diameter 1·40in.
(*d*) Type D ; overall diameter 1·21in.
(*e*) Construction of type D cable.
A—Centre conductor ; 0·1318in diameter copper.
B—Three 0·0145in copper surround tapes.
C—Polythene to 0·620in diameter.
D—Six 0·016in copper return tapes.
E—0·003in overlapped copper teredo tape.
F—Gapped Telconax tape.
G—One serving of cutched jute.
H—Twenty-four 0·086in diameter high-tensile steel armour wires.
J—Two impregnated jute servings.

Fig. 3—Types of cable

Signalling over the cable circuits will be designed to allow co-ordination between the different national long-distance signalling systems at the ends.

Clarenville-Oban Section

As already indicated, two cables will be used between Newfoundland and Scotland, one for each direction of transmission. These and the associated repeaters will be of the type now in operation between Key West and Havana and have been described in some detail in the literature.[1]

Cable.—The evolution of the cable design has been described [earlier in the paper]. The cable to be used on the transatlantic route will have a somewhat greater thickness of dielectric than that included in the make-up of the Key West-Havana cables and will be 0·620in in diameter.¶

Manufacture of the cable will demand control of the dimensional tolerances to a greater degree of precision than has been attempted hitherto, because the large number of repeaters in circuit make it of great importance to maintain a fine balance between repeater gain and cable loss. Predetermination of the effects of temperature and pressure on cable attenuation will enable this fine balance to be obtained when the cable is at sea-bottom temperature and pressure. Impedance irregularities must also be avoided, since they affect the gain/frequency characteristics of the repeaters.

As is customary in cable practice, special cable armouring will be used near the shore ends, and the various types of armouring are shown in Fig. 3. Type A cable has an armouring consisting of twelve galvanised mild steel wires, each 0·3in in diameter, and is laid in water not deeper than about 300 fathoms ; type AA, used for the landing, is similar, but has an extra layer of armouring. Type B is laid in moderate depths and has eighteen galvanised mild steel wires, each 0·165in in diameter. Type D is laid in all depths greater than about 700 fathoms ; it is armoured with twenty-four high-tensile steel wires of 0·086in diameter, each wire being taped, and these enable it to be laid and lifted in the deepest water.

Repeaters.—The desirability of a flexible type of housing was referred to [earlier in the paper]. The structure which was finally evolved is a flexible bulge in the cable 8ft long and 2·8in in diameter, tapering for a distance of about 20ft at each end down to the cable diameter. The armour of the cable itself is continued over the repeater housing, but with armour wires added to give complete coverage. To prevent the twisting of the repeater structure in the laying operation, there is a second layer of wires with opposite lay. The repeater itself is enclosed within an 8ft-long series of cylindrical sections inside the housing.

The structure of the repeater container is shown in Fig. 4. The whole structure is flexible, and passes readily over the cable drum and bow sheave without requiring that the ship be stopped. To attain this flexibility, the repeater elements within the container are mounted inside a series of Lucite (methyl-methacrylate) cylinders, succesive units being held together by a spring assembly to form an articulated system. Surrounding this series of Lucite cylinders is a series of butt-ended steel rings, in two layers, the joints between successive rings in the two layers being staggered. Over the rings, and supported by them against collapse at sea-bottom pressure, is an envelope in the form of a copper tube, over which are the protective coatings and armouring wires.

The repeater enclosure is terminated at each end with a system of seals, comprising first a glass-metal seal adjacent to the repeater elements, then a plastic seal moulded to the cable insulation and finally, at the extreme ends, a 7ft long seal formed within a copper tube which is an extension of the repeater housing. In order to penetrate the housing, sea water would therefore have to thread a long multi-barriered path. All seals are adapted for the sea-bottom pressures that they may have to withstand.

The fifty-two repeaters in each cable will be located at intervals of approximately 37 n.m. They will be fed with d.c. power originating at each shore end, the power feeding arrangements being described below. Each repeater will produce a voltage drop of 55V at a current of 225mA initially, but after a number of years the current can be increased to a maximum of 245mA (64V per repeater) to offset any deterioration in valve emission.

Testing Arrangements.—Frequencies in the range 167-174 kc/s will be used to keep track of the performance and condition of individual repeaters by means of measurements made from the shore ends. The techniques for doing this have been outlined in earlier articles describing the Key West-Havana system.[1] Briefly, the device used is a quartz-crystal resonator shunted across the feedback circuit of the repeater so as to remove feedback effectively over a very narrow frequency band which is different for each repeater. In this narrow band the gain is much higher than at all other frequencies and is very susceptible to changes in valve characteristics. Thus, system gain measurements at the various crystal frequencies provide a means for detecting, in each repeater separately, small changes in significant valve parameters which would not be disclosed with normal feedback. At the same time, the high gain at resonance creates a series of thermal-noise peaks at the crystal frequencies. These can be observed by a narrow-band detector at the receiving end of the cable and will provide a means for locating repeaters which have failed. To accomplish this, it is only necessary to note the missing noise peaks, since these are associated with the repeater which has failed and those preceding it. In order to make this test possible even when the failure is caused by an open-circuit heater, a gas diode is provided in each repeater to by-pass the power supply current.

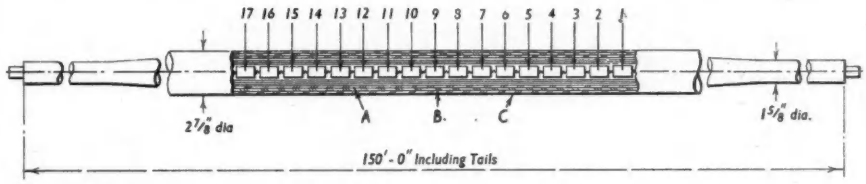
Repair Repeaters.—If the cable is damaged during laying or in operation, it will have to be raised and repaired. After the repair, the cable length in the repaired section will be greater than before, and this will upset the balance between cable loss and repeater gain. In the deepest water, the extra cable length may amount to several miles, and to compensate for the additional loss, low-gain "repair repeaters" are being provided. One of these will be inserted when a repair is made in deep water.

Clarenville-Sydney Mines Section

The frequency bands to be transmitted over the single cable between Newfoundland and Nova Scotia are those used by the British Post Office in most of its shallow-water schemes, except that the bottom frequency band is lowered by 4 kc/s so that the three transatlantic groups can occupy the same frequency band as on the section between Newfoundland and Scotland ; this will simplify the frequency-translating equipment.

Submarine Cable.—The structure and dimensions of the conductors and core of the submarine cable will be identical with those of the cable used between Clarenville and Oban ; the cable will have A or B type armouring (Fig. 3). It will, however, be tested to a specification appropriate to the higher frequencies to be transmitted and having regard to the fact that some slight easements are possible because the impedance of the repeaters in this section will approximately match that of the cable.

Land Cable.—The land cable will be basically the same as the submarine cable, but, being more subject to electrical interference, it will be screened with layers of soft iron tape applied over the outer conductor. The tape in turn will be protected from corrosion by a polyethylene sheath, over which will be applied jute bedding and armour wires. The cable will be laid in a trench at a depth of approximately 30in, where the temperature is expected to have an annual variation of about 35 deg. Fah. and a maximum daily variation of about 2 deg. Fah. Guard



Repeater-unit sections.
1. Input terminal.
2. Input blocking capacitor.
3. Earthing capacitor.
4. Crystal.
5. Input network.
6. First-stage pentode.
7. First inter-stage network.
8. Second-stage pentode.
9. Second inter-stage network.
10. Third-stage pentode.
11. Output network.
12. Feedback network.
13. Feedback network.
14. Gas diode.
15. Drier.
16. Output blocking capacitor.
17. Output terminal.

A—Armour bedding and corrosion protection. *B*—First layer of armour wires. *C*—Second layer of armour wires.

Fig. 4—Repeater, Clarenville-Oban section

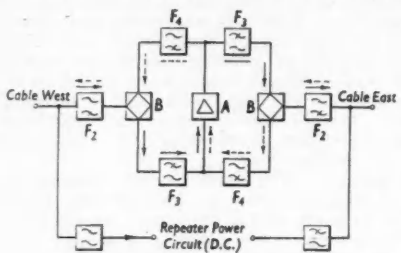
‖ Slightly displaced to avoid carrier leak.
¶ Cable dimensions refer to the core diameter before the addition of the outer conductor.

wires, for protection of the system against lightning, will be laid in the trench above the cable. The two repeaters in the land section will be identical with those in the sea and, according to the terrain determined in the final survey, will be laid in ponds, buried in the ground or located in small manholes.

Repeaters.—The mechanical design of the repeaters which will be used in this section is shown in Fig. 5. The electrical equipment is mounted in an inner sealed cylinder 4ft 2in long and 7¾in in diameter, filled with dry nitrogen. It is mounted between brazed-in bulkheads in the pressure-resisting outer housing, which is about 9ft long and has a maximum diameter of 10½in. The glands are polyethylene mouldings which are integral with the cable dielectric and which are shrunk on to castellated bosses, previously treated so as to form a bond with the polyethylene. The cable armouring wires are made-off under clamps, which transfer the laying tension to the housing; the design of these clamps is adequate to permit of laying the repeaters at ocean depths, although, of course, such strength will be unnecessary for cable-laying operations between Newfoundland and Nova Scotia.

The sixteen repeaters in this section will be located approximately 20 n.m. apart. Electrically they will be arranged to give both-way amplification, as shown in Fig. 6. A feature of the design is the inclusion of balanced bridges at each end of the repeater, which not only supplement the directional discrimination in the filters by a minimum of 20 db, but also contribute substantially to the equalisation. The bridges also have the advantage that the intermodulation requirements in the filters are reduced so that small high-Q-factor ferromagnetic-cored coils can be used. Apart from the equalisation provided by the directional bridges, the repeater derives most of the necessary gain/frequency characteristic from the two-terminal feedback network.

There are two three-stage amplifier units in parallel between common input and output transformers with a single feedback path. The feedback network will maintain the repeater gain if one amplifier unit becomes inoperative, but the overload point is reduced by 5 db under this condition; a faulty component in one amplifier unit cannot affect the other unless it introduces circuit noise. In comparison with a system using single amplifiers, the probable life of each repeater is increased and the probability of early faults on the system is greatly reduced, as shown theoretically in the Appendix to an earlier paper.[2]



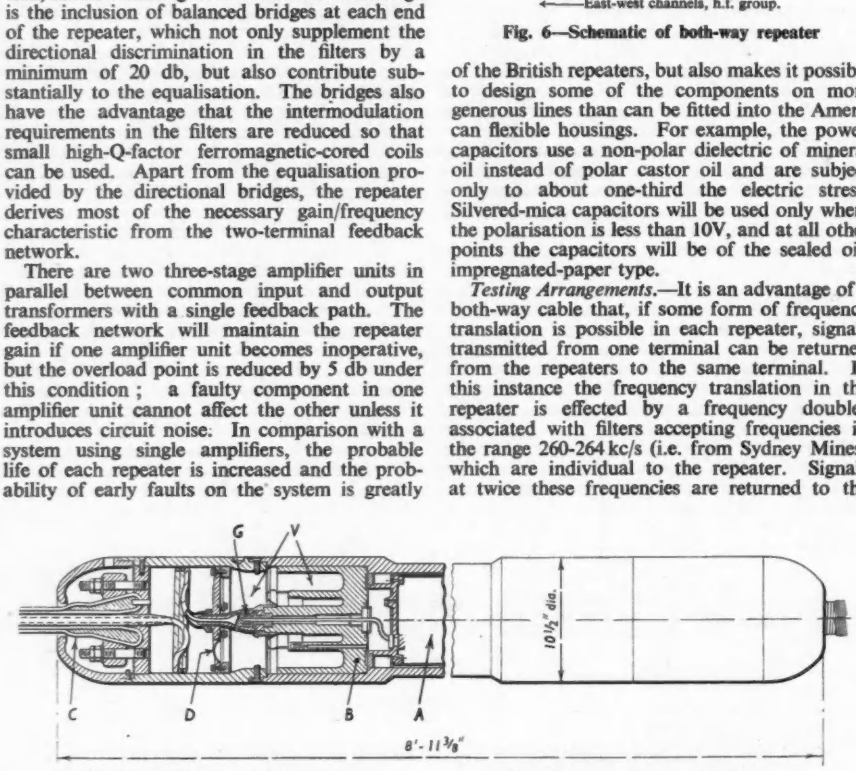
A—Amplifier.
B—Balanced bridge.
F_3, F_4—Low and high-pass power filters.
F_1 F_2—Low and high-pass directional filters.
——→West-east channels, l.f. group.
←——East-west channels, h.f. group.

Fig. 6—Schematic of both-way repeater

of the British repeaters, but also makes it possible to design some of the components on more generous lines than can be fitted into the American flexible housings. For example, the power capacitors use a non-polar dielectric of mineral oil instead of polar castor oil and are subject only to about one-third the electric stress. Silvered-mica capacitors will be used only where the polarisation is less than 10V, and at all other points the capacitors will be of the sealed oil-impregnated-paper type.

Testing Arrangements.—It is an advantage of a both-way cable that, if some form of frequency translation is possible in each repeater, signals transmitted from one terminal can be returned from the repeaters to the same terminal. In this instance the frequency translation in the repeater is effected by a frequency doubler associated with filters accepting frequencies in the range 260-264 kc/s (i.e. from Sydney Mines) which are individual to the repeater. Signals at twice these frequencies are returned to the sending terminal and enable an accurate measurement to be made of the transmission level at the output of each repeater at any time.

Pulse-testing equipment will also be provided at each terminal to permit measurements of the overload point of each repeater. The repeaters will be identified on a time base and the frequency translation effected by the overload distortion of the amplifier itself. This test can be carried out in either direction, by direct harmonic production in one direction and by intermodulation of a two-tone signal in the other direction; it is aimed primarily at determining whether both amplifiers are functioning in each repeater.



A—Inner unit enclosing electrical apparatus.
B—Bulkhead (brazed in).
C—Armour clamp.
D—Flexible diaphragm enclosing Vistac, V.
G—Castellated gland.

Fig. 5—Repeater housing for Clarenville-Sydney Mines section

Power Feed to Repeaters

The arrangements for feeding power to the repeaters on the two sections are generally similar and involve the use of constant-current generators at both terminal stations, series-aiding and arranged so that one end controls the value of the line current (Fig. 7).

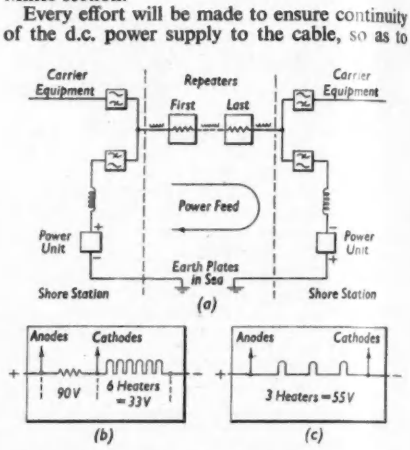
The repeaters on the Clarenville-Oban section will require initially a total driving voltage of about 3900V, increasing later to about 4450V, or up to about 4700V if it is necessary to introduce additional repeaters after repairs; the maximum voltage on the cable will be half of this. For the repeaters on the Clarenville-Sydney Mines section the necessary total driving voltage will be about 2300V and, if necessary, it will be possible to feed this from one end only, since the power capacitors are adequately rated.

The constant-current generators used on the two sections will differ in several respects. Those on the Clarenville-Oban section will derive the constant-current feature by feeding via high-impedance pentodes with a mechanical regulator to absorb all but short-term variations. In order to assist continuity of the line current, the load will be shared by two generators at each end, each generator being capable of taking the full load. Transductor-controlled power units will be used for the Clarenville-Sydney Mines section.

Every effort will be made to ensure continuity of the d.c. power supply to the cable, so as to avoid voltage surges at the repeaters, and in order to assist this the a.c. supplies to each power-feed unit will be derived through a.c./d.c./a.c. machines. These machines will be normally driven from the supply mains, but in the event of mains failure, diesel-engine-driven alternators will be started up automatically. There will be two stages of standby:

(*a*) The a.c./d.c./a.c. machines will continue to run, driven from a 130V battery which energises the d.c. machine.

(*b*) If the mains failure is of long duration, the standby diesel plant will take over.



(*a*) General schematic.
(*b*) Repeater power circuits for Clarenville-Sydney Mines section.
(*c*) Repeater power circuits for Oban-Clarenville section.

Fig. 7—Basic power-feeding arrangements

Cable Laying Arrangements

All the cable will be laid by H.M.T.S. "Monarch." This ship, which was built for the British Post Office in 1945,[4] has a gross tonnage of 8056 and, with full oil bunkers, can carry between 5000 and 6000 tons of cable.**

"Monarch" is the only cable ship afloat capable of laying the whole of the deep-water part (about 1500 n.m.) of each cable between Newfoundland and Scotland in one operation. From earlier sections of the paper it will be obvious that it is desirable to avoid any sequence of operations which will make it necessary to pick up a cable end and to make a splice in deep water. Such operations will have to be carried out if repairs are necessary after the cable has been laid, but inevitably introduce some risk of the cable kinking; the initial laying will be planned to avoid them. All repeaters will have been jointed into the cable before it is loaded into the ship.

A period of twelve days during which continuously good weather conditions may be anticipated is necessary in order to carry out the main operation without undue hazard to the

** The tons referred to here, and in the paper generally, are long tons of 2240 lb.

repeatered cable. In the North Atlantic such conditions are unlikely, except during the period from mid-May to mid-September, and it will not be practicable to lay both the cables on the main crossing in one summer. It is planned to lay one of these cables during the summer of 1955 and to complete all cable laying operations in 1956.

Although the flexible built-in repeaters are designed to be handled as part of the cable, it is, of course, desirable not to bend them to a small radius. New cable drums of approximately 7ft diameter are being fitted on the "Monarch," this being the largest size that can be accommodated without major structural alterations. Bow and stern cable sheaves will also be made this diameter. Roller guides with a minimum radius of 3ft 6in will replace the existing spider wheels and "spectacle" guides throughout the ship, in order to ensure freedom from sharp bends and an easy run of cable from the tanks during laying. Various devices which proved successful when laying the Key West to Havana cables will be fitted to ensure that the repeaters conform to the curvature of the cable drums and to ease their passage round the drums and at other points.

Three new dynamometers will also be fitted, two forward and one associated with the paying-out gear aft. Sheaves of 7ft. diameter will be used, associated with electrically sensitive pressure cells. The latter will be arranged to operate indicating and recording instruments on deck and in the test room, and will enable the tension on the cable to be controlled closely as it is paid out.

The laying of the cable between Newfoundland and Nova Scotia will present no special problems, but an electrically driven hoist has been fitted over the ship's bows to facilitate handling the rigid repeaters.

Connection to Internal Telephone Networks

From Oban the transatlantic circuits will be taken to London by carrier cable; there will be two alternative routes, one via Glasgow and the other via Inverness and Aberdeen. In London it will be possible to connect any transatlantic circuit to any one of the existing submarine cable circuits to the Continent of Europe, thus providing through cable communication between North America and continental Europe. On the American side a microwave radio relay system will connect Sydney Mines with Portland (Maine). This type of system, which makes use of line-of-sight transmission between relay stations, has already been extensively installed in the United States as a means of providing long-distance telephone circuits of the same quality as cable circuits. From Portland the circuits will be extended to New York by carrier cable or radio relay. Cable connection to Montreal will be effected at a point on the radio relay system near the United States-Canada border.

Conclusion and Speculation

Barring unforeseen and unexpected delays, 1956 should see the completion of the first transatlantic telephone connection via submarine cable. With the completion of this project, telephone service between the two continents should enter into a new era marked by improved quality of service and reliability, and a capacity for growth no longer restricted by the limited capacity of the radio spectrum. However, the advantages of radio—flexibility, the speed with which communications can be established and shifted from route to route, the feature of direct access from one country to another, relatively low cost, &c.—will remain. These are not inconsiderable advantages and they augur well for the continued importance of short-wave radio telephone services.

On the other hand, the new transatlantic cable will by no means represent all that could be done if full advantage were taken of contemporary techniques. The submarine cable art is a conservative one. As Dr. Buckley observed, the laying of a submarine cable, like any other activity on the high seas, must be planned with its unavoidable hazards in mind. Experience over 100 years has shown that when handling deep-water submarine cables on the high seas it is better to be safe than sorry.

But the consequences of this doctrine of caution are equally plain. The submerged repeaters in the 1956 deep-water cable section incorporate valves whose proven design dates back to 1941, and with a mutual conductance of 1000 micromhos. On the other hand, "conservative" post-war valves provide mutual conductances of about 5000 micromhos, and valves, having a slightly better performance than this will be used in the cable system between Newfoundland and Nova Scotia under conditions where the consequences of valve failure will be minimised. The integrity of such post-war valves under the severe and highly specialised conditions of installation and use encountered in submerged repeaters remains to be established. On the other hand, it is without question that, with such new valves, cable systems having still greater communication capacity can be realised.

Looking still further ahead, the transistor looms as a development which has the potentialities for making possible long deep-water submarine cables with much greater communication capacity than can be realised with repeaters employing thermionic valves. The voltage required by the valves sets an upper limit on the number of them that can be operated in tandem before the power supply results in voltages on the cable that are beyond the limits of safety. The much lower power drain of the transistor should overcome this obstacle and permit more repeaters to be used and wider frequency bands to be transmitted. Ruggedness, long life and small size are added attractive features of the transistor which are of not inconsiderable important to the future development of submarine cables.

A transatlantic submarine television cable is a long-range goal worthy of serious study and by no means to be dismissed as impractical of eventual attainment.

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Aluminium Underground Cars for Toronto

Four aluminium alloy cars have just been completed for the first Canadian underground railway system in Toronto. These cars were designed and built by the Gloucester Railway Carriage and Wagon Company, Ltd., which also supplied all of the 100 steel cars now in service. It was decided to introduce these four aluminium cars, with two more to follow, in order to assess the economics of aluminium construction for this type of vehicle in service. The new cars are similar in general design, capacity and power to the steel ones, so that a direct comparison of performance and operating costs will be possible. The use of aluminium has resulted in a weight saving of 5½ tons per car, reducing the weight of the superstructure, complete with all equipment, from 22¼ tons of the steel vehicles to 16¾ tons. To assess comparative power consumption, meters have been fitted in the aluminium cars and in four steel cars.

In the standard cars used in Toronto, an operating unit consists of two cars, one carrying the air compressor and the other the auxiliary motor generator set; a train may comprise up to four two-car units. The cars are 57ft long and over 10ft wide, with seating for sixty-two passengers and a total capacity of 230. Four 68 h.p. frame-mounted traction motors power each car and automatic retardation control is provided.

For the aluminium cars, the economics were investigated by the Aluminium Development Association, and recommendations were later made by the Association and by Northern Aluminium Company, Ltd., which supplied the structural material. Aluminium alloys, in the form of fully heat-treated sections, plate and sheet were used for all structural members above the bogies with the exception of the main bolster, which is in steel. In building extensive use was made of argon-shielded tungsten arc welding process, whilst for the riveted joints aluminium alloy rivets were employed. The attachment of the external panelling is of special interest, the edges of the panels being butt welded and attached to the framing by riveting. A high initial finish was required in riveting as no filling or painting was to be done on the vehicles, and the methods adopted successfully rendered the lines of rivet heads imperceptible on the finished cars.

Canadian Engineering News

(By our Canadian Correspondent)

The twelfth annual convention of the Municipal Engineers' Division of the B.C. Engineering Society took place in the Okanagan city of Kelowna, British Columbia, on September 16th, 17th and 18th. More than 200 delegates attended the gathering, under the chairmanship of G. W. Meckling, P.Eng., Kelowna's municipal engineer. Mr. Goode, public health engineer for the provincial government, speaking on "Sewage Treatment," referred to the increasing pollution of B.C. waters, despite the abundance of water resources, stating that as the use of provincial water reserves increased, so the capacity of the streams to assimilate wastes decreased, and the sewage disposal problems of municipalities were thus aggravated. A particularly interesting talk was given by Mr. Libby on "External Underground Pipeline Corrosion." Listing the causes, he brought out the following:—Reaction of different materials in accordance with electromotive series; different surfaces of the same material; differing electrolytes; differences in degrees of hardness and stress; aeration and irregular currents; long line current, and corrosion due to anaerobic action. Speaking of the science of corrosion engineering, he said that the fundamentals of the reactions were the principles of the dry cell, and that pipeline coatings were actually materials of electrical insulation. The 1955 meeting is scheduled to be held in Nanaimo, Vancouver Island, under the chairmanship of A. P. Leynard, P.Eng., city engineer of that city.

* * *

A steel and concrete crib pier, fog alarm and lighthouse is being constructed at White Island Reef, Quebec, in the St. Lawrence River. The contractor for this pier construction is the Foundation Company of Canada, Ltd., with the steel crib subcontracted to Davie Shipbuilding, Ltd., Lauzon, Levis, P.Q. The unit consists of a steel crib with an 80ft diameter base, and with a 56ft diameter top section, which is the flooring platform for the actual lighthouse structure. Weighing approximately 250 tons, the height of crib is 67ft, which is in form a truncated cone with an inverted smaller truncated cone acting as the flooring structure. It is of ¼in and ⅜in steel plate, and will be sunk on the site, being filled by pressure-grouted crushed stone. Prior to launching, to ensure stability, a reinforced concrete base was necessary, approximately 1000 tons of concrete being poured prior to launching. After launching the balance, about 2000 tons, was poured. The unit will house navigational aids, and necessary personnel, in its superstructure.

* * *

A Canadian consulting engineering firm, working in conjunction with a London corporation, has been carrying on an engineering survey of the hydro-electric potential of British Guiana. Working with the Colonial Development Corporation, of London, with which Mr. F. J. Bartholomew, Vancouver, stated he had been in association for several years, they have confirmed the large potential of the country and have a 10,000 h.p. scheme under consideration. The firm, which bears Mr. Bartholomew's name, is designing the first step, a 2200 h.p. unit of a hydro-electric plant, the potential output being 4500 h.p. This power plant is located on the Potaro River, at the Turnatumari Rapids.

"Dyseac" Electronic Computer of the National Bureau of Standards

(By Our American Editor)

The "DYSEAC" high-speed digital electronic computer was developed by the Electronic Computers Laboratory of the National Bureau of Standards to serve as both a versatile tool for solving various system-simulation problems and as a proving ground for evaluating certain logical component design methods and packaging techniques. The circuitry of the computer has been reduced to standardised etched-circuit plug-in packaged units. It uses electrical delay lines for all incidental pulse storage and transformer-coupled pulse amplifiers having only one valve each. The computer was delivered for use by the U.S. Army Signal Corps earlier this year.

IN developing the "DYSEAC" high-speed digital electronic computer, the National Bureau of Standards utilised electronic circuits similar to those used in its "SEAC" computer. These circuits were based on the performance of all logical operations by diode gating, the use of electrical delay lines for all incidental pulse storage, and the use of transformer-coupled pulse amplifiers, using only one valve for all amplification. In the case of "DYSEAC" this circuitry has been reduced to standardised packages. Only two kinds of etched-circuit plug-in packages are required as basic building blocks in this machine. Thus it has been possible to use modular construction throughout the computer and to simplify design practice, construction and maintenance.

"DYSEAC" is similar to "SEAC" in several other respects. It operates at a basic repetition rate of 1 Mc/s, uses a serial mode of data representation and employs a serial acoustic memory. However, its operating capabilities have been extended considerably beyond those of "SEAC" by the incorporation of several special logical design ideas, whereby the computer can communicate in an extremely flexible manner with a large group of external devices performing many diverse functions. Among the devices which may be attached to the computer are those that store, tabulate, file, convert, display, and sense information; or devices that actuate mechanisms such as servo-equipment in response to signals sent out by the computer as a result of information being processed within it. Even other full-scale computers employing the same digital language may be attached to this machine. The new computer has been designed so that communication between any of these external devices and the central computer (or between the central computer and the persons operating it) can take place at any time, on a completely unscheduled basis. Such impromptu interchanges of information can be instigated either by the central computer or by the external world communicating with it, or by both acting jointly. This facility enables the computer to respond to, as well as to control, the family of external devices which can be annexed to it. In response to the activities of these external devices the computer can interrupt or alter its internal programme at any time in order to redirect or assist them as the work progresses. Consequently, the computer can be used to co-ordinate the several activities of the external devices into an effective joint operation.

An unusual external device which has actually been attached to "DYSEAC" is the "SEAC" computer. One complete experimental run was made, which demonstrated the ability of "DYSEAC" to respond to monitor signals originating in "SEAC" and to interrupt its programme to receive and process data from "SEAC." The two machines were thus made to work co-operatively on a common task which involved preliminary processing of data by "SEAC," transmission of these data and programme information from "SEAC" to "DYSEAC," and further processing by "DYSEAC." "DYSEAC" worked on an entirely different task during the intervals in which it waited for "SEAC" to transmit additional data. This other task involved operations which simulated an independent productive programme running concurrently with the shared programme.

The arithmetic powers of "DYSEAC" have not been greatly expanded over those in "SEAC." Instead, major emphasis in design was placed on providing versatility of control facilities and latitude for expansion. It was deemed important to provide for a future expansion of the high-speed internal storage capacity in case this should become important for a particular application. Accordingly the system has been provided with convenient means for supplementing the initial memory capacity of 512 words with additional storage units up to a total capacity of 4096 words. The engineering properties of "DYSEAC" are directly related to its intended use as a data processing centre which can be placed at various operating sites without particular difficulty. The equipment is distributed between two 40ft trailer vans. The major portion of the equipment—three computer racks, the memory cabinet and the control console with input-output facilities—is installed in the computer van (Fig. 1). The second van houses regulated d.c. power supplies and provides a general-purpose area for special equipment, storage and work space. Each van also has its own air conditioning equipment. Thus, "DYSEAC" is a self-contained unit, and, thanks to the provision of a mobile power plant consisting of two 50kW diesel engine-driven generators, it can be operated in completely isolated areas. The three racks and the memory cabinet are shock-mounted to reduce the possibility of damage from road shock and vibration during transport from one operating site to another.

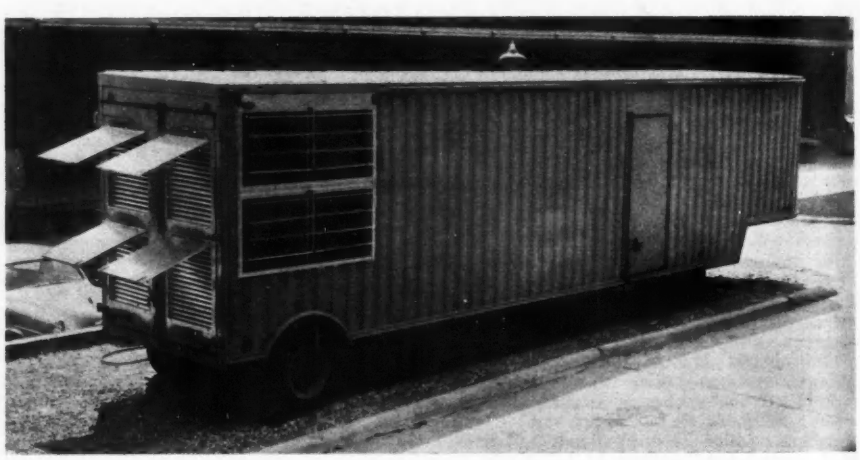


Fig. 1—The 40ft trailer van carrying "DYSEAC" computer equipment

Functional Organisation

The computer is organised around the high-speed memory (Fig. 2). This unit receives and distributes to the other internal units the information (numbers and instructions) to which the most rapid access is needed for carrying out the work of the machine. The memory communicates principally with five major units of the system. Of these, two are primarily concerned with internal processing activities and three with external relations. A continuous flow of digital information may be maintained simultaneously between the memory and the inward-looking and the outward-looking units. The latter serve to communicate with the external devices and include the input-output buffer, the external selector, the concurrent input-output control, the display staticiser, and the serialiser.

The input-output buffer transmits information at the proper repetition rates from the external unit to the internal memory during an input operation and in the reverse direction during an output operation. The buffer receives words from the memory at the normal internal repetition rate of 1 Mc/s and then transmits them, digit by digit, at the measured rate appropriate to the external unit. The external unit itself specifies the word format and the repetition rate appropriate to it.

The external selector is a high-speed switching device and selects the external unit with which an input-output operation is to be performed. It provides the signal required to complete the circuit connections for the lines carrying both the digital information and the control signals needed to operate the external unit. The external selector is capable of selecting among forty-eight external mechanical relay switches, but it can be expanded to handle 256 distinct information channels, such as individual parallel magnetic drum channels or high-capacity magnetic filing systems.

The concurrent input-output control regulates the detailed progress of all input-output operations requested in the course of the internal programme. It directs the flow of traffic between the memory and the input-output buffer, and between the buffer and the external selector.

The display staticiser and the serialiser are specialised input and output organs adapted especially for "real-time" operations. The display staticiser is a register storing twenty-eight binary digits in parallel for controlling, for example, a digital-to-analogue converter which provides deflection voltages for a cathode-ray tube visual display. The serialiser unit is provided for continuous external input devices. It can accept one full word of forty-five binary digits delivered in parallel in the form of asynchronous pulses from an external unit, and can then transmit the work in synchronised normal serial form to any other units of the system capable of reading words out of the high-speed memory.

The arithmetic unit carries out arithmetic or logical choice operations. Arithmetical results are written directly into the high-speed memory, and control signals specifying the outcome of the discrimination operations are sent directly to the programme-sequencing and control unit, where they serve to modify the choice of memory location from which the next instruction is to be read. An additional route of communication to the input-output buffer provides for the loading or printing out of the contents of the arithmetic accumulator register directly, via the electro-mechanical typewriter (Fig. 3) or magnetic input-output units. The remaining unit in direct communication with the high-speed

memory is the instruction register. Instruction words are transferred, one at a time, from the high-speed memory into the instruction register. From this unit information contained in different segments of the instruction word is selected by the programme control unit and transmitted to various other internal units throughout the system, and simultaneously to the concurrent input-output control for checking against possible conflict with concurrent input-output operations.

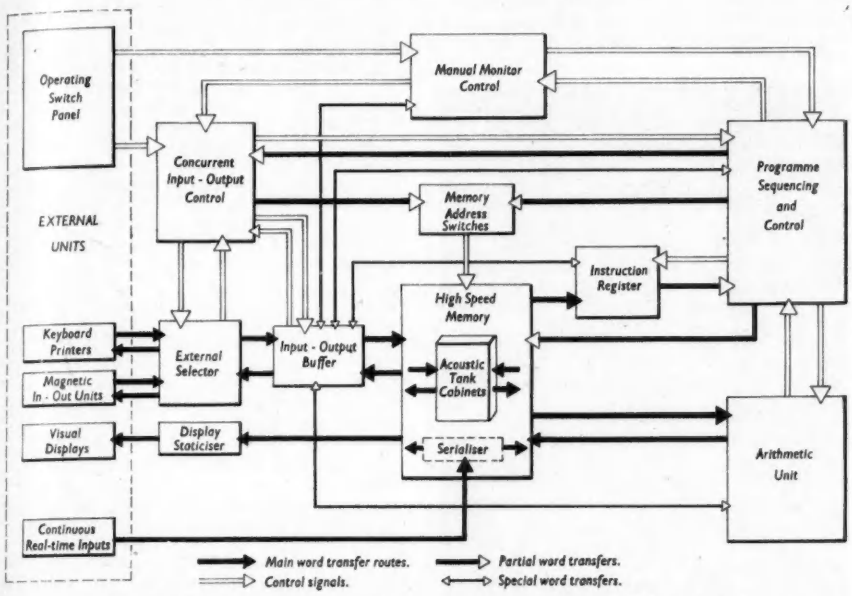


Fig. 2—Block diagram showing basic components of the " DYSEAC " computer

The last major unit in the functional organisation of " DYSEAC " is the manual monitor control unit, which is responsible for regulating and synchronising the carrying out of joint internal-external operations. It interprets the conditions specified by the external switches on the switch panel, under which monitor operations are to be performed ; it observes the progress of the internal programme and recognises when these specified conditions arise ; and it delivers signals temporarily halting the internal programme, if necessary by setting up the required special word-transfer routes and by initiating the specified interpolated internal or external operation.

Logical Design Properties

There are three general properties which provide " DYSEAC " with its control versatility. The first of these is a " concurrent operation " property. External-transfer operations, which transfer information between the computer and the external devices, can be carried out concurrently with internal computing operations and these transfers can refer directly to any area of the internal memory, without restriction as to location or size.

The second property provides for " self-regulation." The pace at which the work programme is carried out within the machine can be automatically adjusted by the computer to the possibly irregular pace at which the external transfer operations are taking place. Whenever it is necessary for the internal and external programmes to proceed precisely in step with each other, the computer can keep the slower-moving external programme abreast of the high-speed internal programme by forcing the latter either to halt or to change its course temporarily. This self-regulation property enables optimum use to be made of the concurrent input-output ability of " DYSEAC " on tasks which require a considerable transfer of information into and out of the machine, or which involve searching through voluminous magnetic files.

The third general property provides for " interruptability." The work programme can be interrupted whenever necessary and a wide variety of special orders can be interpolated into the programme either by the machine operator or by the external devices. This interruption property enables the computer to cope with unscheduled assignments which originate with little or no advance notice in events occurring outside the machine, such as air traffic control applications. These three properties, by their combined presence, create a fourth property of considerable power. Acting in concert, they enable the computer to be employed effectively as a control element in a generalised feed-back loop. These overall properties are derived principally from three special operating facilities of " DYSEAC " : manual-monitor facilities, a programme-control feature and an input-output control feature.

The term " manual-monitor " has been coined to describe certain operations which can either be initiated manually by the machine operator, who, for example, presses a push button on the control console, or can be initiated by the computer itself under conditions which are specified by means of external switch settings on the control console. The former is referred to as a manual operation, and the latter is called a monitor operation because the computer must monitor its internal programme to determine precisely when the operation should be performed. Manual-monitor operations can readily be specified and initiated by external devices as well as by human operators. Furthermore, since all of the external switch settings control only d.c. voltages, the external devices can even be remote from the computer itself, and they can exercise supervisory control over the internal programme of the machine from a distant point.

Five kinds of manual-monitor operations can be performed by the computer : loading-the-memory operations, print-out operations, insert-new-instruction-into-the-programme operations, change - sequence - of - instructions - in-the - programme operations, and halt-the-programme orders. By pairing a particular manual-monitor operation with a chosen set of conditions a wide variety of special operations can easily be performed as the work progresses. For every manual-monitor operation, the external switches on the control console are set to specify not only the operation to be performed and the conditions under which it is to be performed, but also the storage places which are to be involved. These storage places can be chosen from certain available locations in the internal high-speed memory and from five different storage registers in the computer. Thus, by means of the external switches, certain storage areas within the computer itself may be utilised by devices remote from it. These remotely situated devices can direct that information in certain areas of the memory in the computer should be transmitted to them. Similarly, they can insert new information into various portions of the memory. In this way, at the option of either the external

Fig. 3—Control console of " DYSEAC " computer with electro-mechanical typewriter

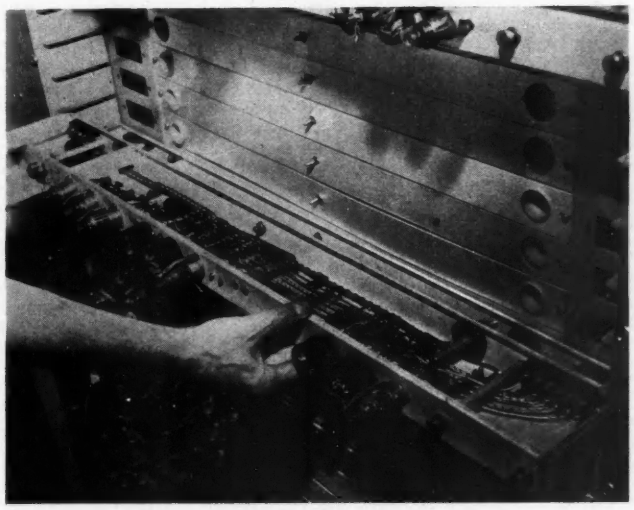


Fig. 4—Acoustic delay-line unit being removed from high speed memory of computer

devices or the machine programme, or of both acting jointly, "DYSEAC" can share with these remote devices its high-speed memory and consequently every other part of its internal computing and external storage facilities.

It is this ability that makes it possible to connect other full-scale computers to "DYSEAC" and to make them all collaborate on a common task. Each member of such a group of computers is free at any time to initiate and dispatch special control orders to any of its partners in the system. As a consequence the supervisory control over the common task may initially be loosely distributed throughout the system and then temporarily concentrated in one computer, or even passed rapidly from one machine to the other as the need arises.

The other two special facilities in "DYSEAC" also serve to couple the machine to its external environment in varied ways. Each of these special facilities provide for a different distribution of authority in controlling the course of the work programme. Programme control, for example, provides for the initiation of an operation by an external device, but assigns authority for the execution of the operation to the computer. Conversely input-output control provides for the initiation of an operation within the computer, but assigns the authority for the execution of the operation to an external device. In the case of the manual-monitor operations just described, both kinds of control relationships are provided. For simple manual operations the external device or the operator exercises full control over both the initiation and the execution of the operation. For monitor operations, however, the request is initiated externally but the actual execution of the operation does not occur until the chosen conditions arise in the course of the internal programme.

Computer Design

During the planning of "DYSEAC" it became evident that there would be considerable advantage in having a transportable machine which could be moved to any operating site. It was therefore decided to install the machine in the two 40ft trailer vans, which are of standard drop-frame construction and have useful inside dimensions of 31ft length, 7ft 6in width and 9ft height behind the drop. The front section, ahead of the drop, is 8ft long and 7ft high. The computer itself requires only 160 cubic feet of the nearly 2500 cubic feet available in the trailer. The cabinets housing the computer and the memory are accessible from all four sides to facilitate repair and maintenance. The entire installation is designed to be energised from a standard three-phase, 208V distribution system. A minimum of 55kVA is necessary for the computer and its associated equipment.

Both the transportability requirement and the packaged circuit design of the "DYSEAC" computer influenced the choice of the air conditioning equipment and the blower system. Each of the circuit packages in the computer may require about 3 cubic feet of cooling air per minute to limit the temperature rise of this air to 25 deg. Fah. Sufficient refrigeration capacity is available to cool both the electronic equipment and the trailer interior with an outside ambient temperature of 105 deg. Fah. The main air distribution blower is capable of supplying about 4000 cubic feet of air per minute at a pressure drop of over 4in of water. Air from this blower is carried through ducts in the false floor of the structure. The computer racks and memory cabinets have ducts which carry this air to the individual package (Fig. 4) through small holes. Because of the high-pressure drop across these small holes it is possible to pull packages from a chassis without appreciably affecting the flow of cooling air to the remaining packages.

Modular assembly and construction techniques have been used throughout the computer. The individual units are assembled into standard removable chassis holding up to eighty packages, which in turn are readily removed from the three racks, each of which contains four chassis. Only two designs of package need be used because of the general similarity of the circuits of most stages. Although many hundreds of stages are required, a single basic valve circuit was found to be adaptable, with minor modifications, to the majority of requirements. This circuit serves as a low-impedance pulse driver, a flip-flop, and for a number of gating functions. This circuit uniformity greatly facilitates the use of mass-produced circuit packages.

The valve "package" consists of an amplifier valve, a pulse transformer, and a number of diodes. Another "package" houses delay lines (Fig. 5) used for the interconnection between the stages. The 524 valve packages and 251 delay-line packages, containing altogether 21,000 diodes and 3800 quarter-microsecond delay-line segments, provide for about 90 per cent of the total circuit requirements of the computer exclusive of the 400 stages in the acoustic memory and the input-output equipment. The memory comprises mercury acoustic delay lines containing eight words each, with a maximum access time of 384 microseconds. It has a minimum capacity of 512 words, stored in a 64-line cabinet and a maximum capacity of 4096 words, stored in eight such cabinets.

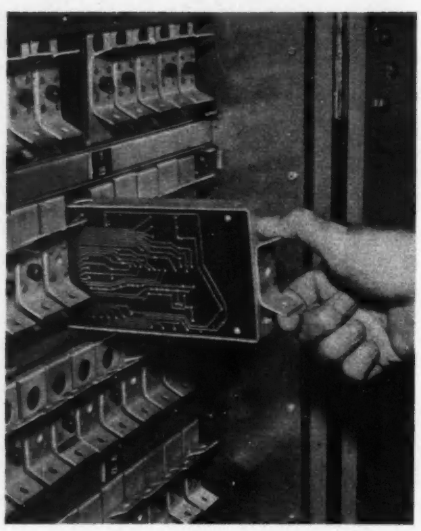


Fig. 5—Standard etched-circuit delay-line package being inserted into computer

Potential Applications

Because of its varied control capabilities, "DYSEAC" can be utilised for investigating many diverse areas of potential application, ranging from the simulation and control of links in a data-communication network to the high-speed processing of business data. In the latter application the main task of the computer might be the automatic routine processing of monthly accounts. The data to be processed would have to be withdrawn automatically by the computer from external magnetically-recorded files, would then have to be properly combined with newer data, and finally the up-to-date information would have to be returned to the files. Even while these operations are progressing automatically, however, the contents of the files would need to be available to the clerical staff of the office for inserting occasional corrections or revisions of data, or for answering scattered immediate requests for information. In some cases the computing services of the computer might be needed for carrying out special minor processing tasks on the data being withdrawn from the files. At the same time, batteries of printers might be systematically going through the files and printing out those portions for which the monthly processing was already complete.

Obviously it would be highly desirable to be able to carry out any of these several operations at will, with as little disruption as possible either to the separate operations or to the main task. Because of the impossibility of foreseeing some operations or the variable operating rates of some of the external devices, it is not possible to schedule in advance the exact time for the actual initiation of these operations or the sequence of their execution. Therefore, in order to operate efficiently, the computer must be able, on a completely unscheduled and intermittent basis, to share both its programme control and its internal storage facilities with its external devices and its human operators. "DYSEAC" is capable of doing this.

Another potential application which requires such capabilities is the control of air traffic at an airport. For this application the human operator can be coupled to the computer (1) through the medium of a visual display device which exhibits graphically the numerical data stored inside the internal memory, and (2) by means of a battery of manual control switches capable of inserting new numerical data or certain new control commands into the computer. The numerical data displayed by the machine represent in real time a map of the predicted traffic patterns in the neighbourhood of an airport, e.g. the predicted locations, based on latest scheduling information, of all aircraft inside a certain area. The human operator can, by means of the manual input controls, enter newer data into the computer as the information becomes available, interrogate the computer for more detailed information concerning certain individual flights as the need arises, and instruct the computer to exhibit the effect to be expected from issuing revised flight control orders. In the latter case parts of the internal information in the machine must be presented to the operator in a rather complex pictorial form in order to be meaningful to him. Applications of this sort, like the previous one, require a constant interchange of intelligence between the computer and its operator, and between the computer and other devices.

A third potential application involves the utilisation of automatic computers for the control of automatic machinery: a first step towards the so-called automatic factory. Here the main tasks of the computer involve: (1) storing the prearranged procedure or series of steps that are to be taken by the automatic factory machinery which is carrying out the manufacturing process; (2) sensing the progress of the machines or the results of their activity on the product being produced; (3) after a complex analysis or comparison of the desired end result with the observed result, determining the appropriate next step to be taken; and (4) issuing appropriate signals which will tend to guide the external tools or regulators in a preferred direction. In the latter case the computer not only is performing many of the functions already described, but also is acting as an element in a feed-back control loop. Since "DYSEAC" has all of these control capabilities, it can be a highly effective tool for exploring these diverse areas of potential application.

Rapid-Response Thermocouple

The development of a thermocouple having a very quick response and of unusually robust construction is announced by the engineering division of the Midwest Research Institute, 4049, Pennsylvania, Kansas City, Mo. It is specially designed for measuring rapid temperature changes on metal wall surfaces, such as gun bores, cylinder and piston walls, brake drums, autoclave walls and air ducts. Its suitability for this class of measurement depends on the fact that a plating of 1 micron (0·00004in) at the junction reduces the response time of the instrument to temperature changes.

It is stated that the time required for the thermocouple junction temperature to reach 63·2 per cent of the amplitude of sudden temperature change of the exposed surface is 0·25 microsecond. The thermocouple has been tested at pressures up to 60,000 lb per square inch under conditions of severe mechanical vibration. Two forms are available: a small one for use on thin walls and a large one for use on thick walls. The development of this instrument formed part of a research programme sponsored by the Chief of Ordnance, Department of the U.S. Army.

Platoro Dam, Colorado.—We have received from the Bureau of Reclamation, Denver, Colorado, a booklet entitled *Platoro Dam: Technical Record of Design and Construction*. A comprehensive account of the Platoro dam is given in this booklet; the dam consists of two rolled earth and rockfill embankments separated by a rock knoll, and it has a maximum height of 165ft. It was built in the years 1949–51.

Industrial and Labour Notes

Eastern Germany's Steel Industry

In the latest number of its *Monthly Statistical Bulletin*, the British Iron and Steel Federation has included a survey of steel developments in Eastern Germany. It says that the iron and steel industry in that territory suffered little damage during the war. The Soviet policy of dismantling and reparations, however, reduced its crude steel production to little more than 100,000 metric tons in 1947, which was about 6 per cent of the 1938 figure. There were only three steel plants which completely escaped the 1945–47 dismantling phase, but since 1948 the re-equipment of the industry, following the reversal of Russian policy, has been surprisingly rapid. By 1952, according to the survey, steel production in Eastern Germany exceeded 2,000,000 metric tons, which was nearly 20 per cent above the 1938 production level.

The survey makes reference to new and extended iron and steel plants projected in a five-year plan for Eastern Germany, and points out that the present economy of the industry is vastly different from that of pre-war days. It shows, for example, that by reason of the changed frontiers the hard coal reserves available to Eastern Germany are small and that the ore deposits are very poor indeed. At present, hard coal is produced only in the districts of Freital-Döhlen and Plöt-Wettin-Lobejün, and also in the mountainous district of Saxony which possesses by far the largest deposits in the country. Eastern Germany's supplies of raw materials are, therefore, insufficient for even the present needs of the steel industry and, the survey says, when the current expansion plans have been fully realised the zone will continue to be dependent on imports.

Imports and Exports

The Board of Trade says that the volume of United Kingdom exports in the third quarter of this year was not significantly different from that in each of the two preceding quarters. For the first nine months of the year the volume was 8 per cent greater than in the corresponding period of 1953. Although comparisons over a long period can only be very rough, the volume of exports this year has been running at a level about two-thirds higher than in 1938.

According to the Board of Trade statistics, the volume of exports of manufactured goods as a whole was the same in the third quarter of this year as in the two preceding quarters, but those classified as " other manufactures " showed a sharp rise in volume mainly owing to the continued upward trend in exports of chemicals. The volume of exports of metals also increased in the third quarter, but exports of engineering products declined somewhat from the high levels of the two preceding quarters, the decrease being partly seasonal. Taking engineering products alone, the volume index number (1950=100) in the third quarter was 99, compared with 104 in the second quarter and 97 for the whole of last year.

The figures show that the volume of imports is probably still less than nine-tenths of its 1938 level, though it was almost as great in the first nine months of this year as it was in the last nine months of 1951 when the highest post-war figures were recorded. The imports of petroleum and petroleum products continue to increase and the volume of arrivals in the third quarter was more than in any preceding period. Imports of basic materials in the third quarter were larger in volume than in the corresponding period of last year, mainly on account of heavier arrivals of timber and pulp and waste paper.

Coal Stocks and Imports

The Minister of Fuel and Power stated in the House of Commons last Monday that distributed coal stocks on October 30th amounted to 17,400,000 tons, which was 800,000 tons less than on the corresponding date last year. He said, however, that there would be a much higher rate of import during the coming winter.

In reply to a question about coal imports, the Minister said that up to the end of October about 2,000,000 tons had arrived. That included 1,250,000 tons of large coal which directly or indirectly assisted the house coal market, and about 250,000 tons of coal costing dollars. About 1,000,000 tons of coal were expected to arrive before the end of the calendar year, of which about half would be large coal and 250,000 tons would cost dollars.

Overseas Commercial Information

In the House of Commons last week, the Minister of State, Board of Trade, Mr. A. R. W. Low, announced the setting-up of an advisory committee on commercial information overseas. Its terms of reference are : " to keep under review the range and character of the information about United Kingdom commercial and industrial activities and achievement which is made available through official and non-official channels to and in the various overseas markets." In the interests of the export trade in particular, the committee will suggest ways in which the information supplied through the existing official channels can be improved, including that supplied by industry, and will also explore the possibilities of increasing the information supplied through non-official channels. The committee's recommendations are to be reported " from time to time " to the President of the Board of Trade. Mr. Laurence Heyworth is the chairman of the committee, the other members being Sir Richard Costain, Sir Patrick Hamilton, Mr. J. Douglas Hood, Mr. Hubert Oughton, and Mr. Claude Wallis.

State of the Ironfounding Industry

The tenth annual report of the executive committee of the Joint Iron Council has just been issued. It says that the year ended June 30, 1954, was the first complete year since the war in which buyers' market conditions have applied to most sections of the ironfounding industry, and also affected the demand for some grades of pig iron. This transformation of the balance between supply and demand, the report records, has been brought about with only a relatively minor fall from the peak outputs achieved during 1951 and 1952. As well as the fall in demand which this drop represents, the effective productive capacity of the iron-foundries was greatly expanded at about the same time by the larger tonnages of pig iron and scrap which became available. As a result, the report adds, the level of ironfounding output is now almost solely determined by the state of demand, and a much greater output is attainable if required.

The report goes on to say that in the present outlook there is little sign of any rapid expansion of ironfoundry output. During the last few months of 1953 there was a halfway recovery in the overall rate of production from the lowest recession levels, but during the first half of this year the position was no more than maintained. The industry's total output for the year ended June 30th last, however, was 3,670,223 tons, which was slightly in advance of the preceding year. On that basis, the report comments, output for the calendar year 1954 will probably reach about 3,700,000 tons, or 1·7 per cent more than the 1953 output. It is stated that certain sections of the ironfounding industry's output, notably in the engineering field, have not kept pace with the expansion achieved by their user industries. This may be due, it is suggested, to temporary causes quite apart from any permanent loss of markets, such as the tendency of many users to hold smaller stocks of castings as supplies became easier. Steel, of course, has become more freely available, a factor which has intensified the competition iron castings are having to face in some fields. It is also observed in the report that, during the year 1953–54, there was some tendency for scrap to be substituted for pig iron.

The report says that during the year the iron-founding industry's labour force fell by a further 2118 to a total of 139,002 workers. This, it is remarked, is the first time that the labour force has been below 140,000 since 1947. Over the last two years or so, the labour force in the iron-founding industry has fallen by considerably more than output. Although, of course, this reflects a higher tonnage output per man-year, it is a situation, the report observes, which " must give cause for anxiety for the future should a re-expansion in the labour force be required."

Locomotive Men's Wages

On Thursday of last week, the Railway Staff National Tribunal began its inquiry into the claim for increased wages put forward by the Associated Society of Locomotive Engineers and Firemen. In the settlement on railway wages generally, which was reached recently by the British Transport Commission and the three railway unions, the A.S.L.E.F. signified formal agreement, but held to its decision that the tribunal should consider its outstanding claim.

The majority of locomotive drivers and firemen on British Railways are members of the A.S.L.E.F., though a small proportion belong to the National Union of Railwaymen. It is stated that the A.S.L.E.F. is asking for £10 5s. a week for the highest paid drivers, an increase of £1 6s. 6d. on the existing rate. The British Transport Commission has offered a basic rate of £9 5s. a week. Mr. Baty, secretary of the A.S.L.E.F., in making his statement to the tribunal, claimed that the level of wage rates of locomotive crews constituted the most grievous anomaly in the whole of the railway wages structure. Young men, he continued, were refusing to enter railway service, and many of those who did enter did not stay long because of the meagre prospects in terms of rates of pay for the job.

Mr. W. P. Allen put the British Transport Commission's case to the tribunal. He said that both the unions which were putting forward claims on behalf of the locomotive men were now seeking increases in excess of the 15 per cent asked for last December. The railway wage increases which had been awarded since 1947 compared favourably with the Ministry of Labour's wages index figures for all workers. Mr. Allen agreed that there was a shortage of footplate men in certain areas, but, he said, the railways were not alone in suffering staff shortages.

Employment and Unemployment

The Ministry of Labour says that the working population of Great Britain increased by 18,000 during September and at the end of the month totalled 23,707,000 (15,990,000 men and 7,717,000 women). There were 836,000 in H.M. Forces and 22,624,000 (15,017,000 men and 7,607,000 women) in civil employment.

The Ministry's analysis of civil employment shows that in September 4,027,000 people were at work in the basic industries, which was 16,000 less than in the preceding month. That reduction was a seasonal one occurring in agriculture and transport. There was, however, a further reduction of 1000 in colliery manpower, the total number on colliery books at the end of September being 705,000, compared with 709,000 a year earlier. In the manufacturing industries, there was an addition of 46,000 to the number employed, the total at the end of September being 9,138,000. The biggest addition, amounting to 21,000, was in the " engineering, metal goods and precision instruments " group, bringing the labour force there to 2,680,000, compared with 2,578,000 a year earlier.

The Ministry's report on unemployment states that on October 11th there were 253,914 people registered as out of work, compared with 236,027 on September 13th. It is estimated that the number of unemployed registered in October represented 1·2 per cent of the total number of employees. The figure included 10,436 who were described as being temporarily stopped.

Notes and Memoranda

Rail and Road

WINTER PROSPECTS FOR FREIGHT TRANSPORT.—The prospective position in inland transport during the coming winter was recently reviewed at a meeting of the Winter Transport Central Joint Conference. This is the body set up three years ago to enable representatives of industry and commerce in consultation with the British Transport Commission to review on a national level the prospects for inland transport during the winter period when freight traffic peaks are apt to coincide with unfavourable weather. The conference works through a central committee on which British Railway Regions as well as British Road Services and Inland Waterways are represented, and has established a national network of district committees where local representatives of trade and industry can meet B.T.C. district officers and take joint action to cope with local difficulties as and when these emerge. The conference noted that some increase was expected in coal and mineral traffic but that railway wagon supply and motive power were likely to be adequate, although the staff position in key operating and motive power grades was still somewhat stringent in industrial areas where the demands of other industries for labour were high. British Road Services had sold some 8000 vehicles and sales were continuing, but the basic organisation would remain in being and would be ready to assist the railways in every possible way if difficulties arose. The vehicles sold were normally taken over by private haulage undertakings, and the capacity they represented was therefore likely to be still available. Inland waterways expected to have some spare capacity and would also be ready to give assistance. On the facts produced, the conference agreed that given reasonable weather conditions, the freight transport available this winter should be adequate, but it was decided to keep the situation under review and arrange for the district committees to meet whenever required.

Air and Water

CORRECTION.—In the description of the "Saxonia" which appeared in our issue of September 24th we inadvertently stated that the oil fuel pumping and heating units were supplied by John I. Thornycroft and Co., Ltd., instead of by British Combustion Equipment, Ltd.

Miscellanea

CONTINUOUS ELECTRODE FOR AUTOMATIC ARC WELDING.—A continuous electrode for mild and medium tensile steels is being marketed by Murex Welding Processes, Ltd., Waltham Cross, Herts, under the name of "Coilex." This electrode has an outer wire winding, which forms a number of small projections above the surface of the extruded flux. These ensure good electrical contact and make it possible to use a greater quantity of flux. The electrode has already been approved by a number of classification societies.

"NIMONIC 90" FOR SPRINGS.—The use of the "Nimonic" series of high-temperature alloys is rapidly extending where high strength at high temperatures is required, and typical of such applications is the use of "Nimonic 90" for springs operating at extreme temperatures. A recent data sheet published by Henry Wiggin and Co., Ltd., presents, in convenient form, tabular data for designers. Copies of the publication can be obtained from the Publications Department of the firm at Thames House, Millbank, London, S.W.1.

LUBRICATION OF EARTH-MOVING MACHINERY.—A new publication issued by C. C. Wakefield and Co., Ltd., 46, Grosvenor Street, London, W.1, is entitled "Earth Moving Machinery Lubrication." It deals in detail with the various parts of a wide range of earth-moving machinery, its operation, care and lubrication, with particular reference to the firm's products. Many useful diagrams and drawings supplement the text matter. All engineers concerned with this class of heavy equipment will find the book of interest and value in their work.

HEAT PUMP AND DISTRICT HEATING.—A short account of the use of the heat pumps for heating buildings, and of the possibilities of the various systems of district heating, is given in a booklet with the above title, published for the Science Masters' Association by John Murray, Albemarle Street, London, W.1. The booklet points out the national significance of these methods of heating in relation to coal consumption, and the need for economy in the use of coal, and it gives details of existing installations in various countries. It is written by V. A. Carpenter and costs 2s.

F.B.I. SCHOLARSHIPS FOR IRAQ.—During the recent British Trade Fair at Baghdad, Sir Norman Kipping, director-general of the Federation of British Industries, announced the first awards to Iraq of engineering scholarships under the F.B.I. scheme. Four scholarships have been awarded to young engineers in that country. The F.B.I. scholarship scheme, it will be recalled, provides for the training in British works of young graduate engineers from the less developed countries. So far, just over fifty scholarships have been awarded, mainly to young men from the major Commonwealth countries and from Latin America.

MANUFACTURE OF AMINE DERIVATIVES.—A plant for the production of a range of cationic and nonionic chemicals is being built at Littleborough, near Rochdale, Lancashire, by Hess Products, Ltd., who operate as licensees of Armour and Co., Chicago. The output of the factory which will go into production next year will be handled by Armour and Co., Ltd., Chemical Division, Lindsey Street, London, E.C.1. In the adjacent fractional distillation plant, Hess Products has made since 1950 the "Distec" range of fatty acids. These will now be catalysed with ammonia to form aliphatic nitrites which by hydrogenation are turned into amines. By reacting the amines with organic acids, water-soluble salts of high surface activity are produced which form the starting point for a wide variety of products, such as bactericidal agents, collectors for ore dressing, asphalt anti-strippers, rust preventatives, and substances used in the rubber, petroleum and plastics industries.

BUILDING LICENSING.—The Minister of Works, Mr. Nigel Birch, made a statement about the future of building licensing in Parliament last week. He said that supplies of building materials had steadily improved during the last three years and productivity in the building and civil engineering industries had risen. Licences had been issued freely in nearly all areas and neither the cost of administering this control nor the inconvenience caused to architects and contractors could any longer be justified. The Government had therefore decided to end building licensing on November 10th.

THE 1954 VISCOUNT NUFFIELD PAPER.—The 1954 Viscount Nuffield Paper of the Institution of Production Engineers will be presented at the Royal Institution, London, on December 9th next, at 6.30 p.m. The speaker will be Major-General W. A. Lord, Director of Mechanical Engineering at the War Office, who will take as his subject the importance of the application of modern production technology and management to the work of the Corps of the Royal Electrical and Mechanical Engineers. Admission to the meeting will be by ticket only, which may be obtained, together with a preprint of the paper, on application to the Secretary, Institution of Production Engineers, 10, Chesterfield Street, London, W.1.

R.A.S.E. RESEARCH MEDAL.—The Royal Agricultural Society of England has decided to offer annually a medal, together with an award of 100 guineas, for research work of outstanding merit carried out in the United Kingdom, which has proved, or is likely to prove, of benefit to agriculture. Recommendations for this award must be submitted to the Secretary, Royal Agricultural Society of England, 16, Bedford Square, London, W.C.1, in January of each year, by the heads of university departments, research stations and institutes and other research establishments. No direct application by candidates will be considered. Recommendations must be accompanied by a brief statement of the candidate's attainments and a list of his publications.

MR. W. M. B. FURNISS.—We regret to announce that Mr. William Marter Burne Furniss, managing director of the Electric Construction Company, Ltd., Wolverhampton, died at his home, The Croft, Sandyfields, Sedgley, Worcs, on November 8th. He was the elder surviving son of Mr. William Marter Furniss, who was chairman and managing director of the company until his retirement last year at the age of eighty-three. Mr. W. M. B. Furniss joined the company in May, 1925, and became sales engineer in 1929. He was appointed assistant manager in 1941 and subsequently he held the positions of general manager, director and manager, and assistant managing director before being appointed managing director in January last.

COAL OUTPUT.—The output of deep-mined coal in Great Britain increased last week to 4,430,600 tons, and with 182,100 tons from opencast sites the week's saleable production amounted to 4,612,700 tons, which was 17,000 tons greater than in the preceding week, but 37,000 tons below the amount produced in the comparable week of 1953. In the forty-four weeks of this year, ended last Saturday, coal output totalled 189,376,500 tons, or about 1,200,000 tons more than in the corresponding period of last year. Coal consumption, including export and bunker requirements, in the first forty-three weeks of this year, totalled 187,338,000 tons, which was nearly 5,000,000 tons more than consumption in the comparable period of 1953.

ELECTRICAL INSTALLATION: MODEL FORMS OF GENERAL CONDITIONS OF CONTRACT.—A new model form of general conditions of contract, known as "Home Cable Contracts, with Installation (E)," has been prepared by the committee on Model Forms of General Conditions of Contract of the Institution of Electrical Engineers, and published by the Council of the Institution. The new form has been designed specifically for use in cable contracts, which include installations, such contracts having hitherto been provided for by the recommended adaptation of model form "A" (Home Contracts, with Erection). It is complementary to Model Form "D" (For the Sale of Cables, without Erection), which continues to be available. Copies of Model Form "E" are obtainable from the Secretary of the Institution, Savoy Place, W.C.2, price 5s., post free.

SOUND INSULATION IN VENTILATING PLANT.—A course of lectures on "Sound Insulation in Ventilating Plant" is to be given at the National College of Heating, Ventilating, Refrigeration and Fan Engineering, Borough Road, London, S.E.1, from January 3 to 6, 1955. The lectures will be accompanied by laboratory demonstrations, and it is stated that, as far as possible, emphasis will be given to the application of the theoretical work to practical problems of sound insulation in ventilating plant. A visit to the acoustics division of the National Physical Laboratory at Teddington is being arranged as part of the course. Applications for admission to the course should be made before December 10th to the college, at the address given above. Residential accommodation is available at the college hostel at 8, Dulwich Wood Park, Norwood, London, S.E.19. The fees are £4 4s. for the lecture course and £4 4s. for hostel accommodation.

Personal and Business

MR. E. S. MACKAY has been appointed manager of the Leicester branch office of British Insulated Callender's Cables, Ltd.

HEAD, WRIGHTSON AND CO., Ltd., Thornaby-on-Tees, announces the appointment of Mr. R. T. Spooner as a sales representative in the Midlands area.

HAYWARD TYLER AND CO., Ltd., Luton, announces the appointment of Mr. G. P. E. Howard as general sales manager. He was formerly the company's general works manager.

MR. ARCHIBALD S. BISHOP has been appointed managing director of Goodyear Tyre and Rubber Company (Gt. Britain), Ltd., in succession to Mr. W. A. Hazlett, who is retiring.

HARD METAL TOOLS, Ltd., and POWDERLOYS, Ltd. (subsidiaries of Wickman, Ltd., Coventry), state that Mr. A. Willott, general manager, has been elected a director of both companies.

BABCOCK AND WILCOX, Ltd., announces the retirement of Mr. B. Samuels, M.I.Mech.E., after fifty-two years in the company's service. Mr. Samuels has had charge of the testing and service department.

THE NATIONAL COAL BOARD announces the appointment of Mr. Noel Gee as director of public relations in succession to Sir Guy Nott-Bower, K.B.E., who has recently retired. Mr. Gee has hitherto been the Board's chief press officer.

MR. W. D. D. FENTON, M.I.E.E., will relinquish his position as secretary and commercial engineer of the North of Scotland Hydro-Electric Board at the end of the year to become deputy chief executive officer of the Uganda Electricity Board.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., announces that Mr. R. S. D. Bagnall has been released, at his own request, from his appointment as home sales director. Mr. L. C. W. Turner, sales director, has taken over the duties formerly carried out by Mr. Bagnall.

ENFIELD CABLES, Ltd., announces the following appointments:—Mr. J. G. Jackson, manager of the Glasgow branch; Mr. F. R. Mackenzie, manager of the Newcastle upon Tyne branch; Mr. W. F. Lawrence, manager of the Southampton branch, and Mr. H. Dennis, manager of the Manchester branch.

JOY-SULLIVAN, Ltd., states that Mr. John R. Bingham, who has been general manager at Greenock for the last two years, has been appointed managing director of the company. Mr. G. H. Burr, European sales manager of the Joy Manufacturing Company of America, has been appointed a director of Joy-Sullivan, Ltd.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., Chelmsford, states that Mr. E. Green has retired from his position as head of the transmitter advanced development group. He will continue his work for the company as a full-time consulting engineer. Mr. V. J. Cooper has been appointed chief engineer, advanced development.

HILLS (WEST BROMWICH), Ltd., states that it has acquired office and factory premises at Back Heaton Park Road, Newcastle upon Tyne, 6 (telephone, Newcastle 59081). Sales inquiries will continue to be dealt with by the firm's area agent, William Mathwin and Son (Newcastle), Ltd., Exchange Buildings, Newcastle upon Tyne, 1.

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., states that Mr. C. Kibblewhite, M.I.E.E., has been appointed an executive director. Mr. G. A. Rendle, M.I.E.E., who has been appointed a director, has become manager (cable contracts) in succession to Mr. C. H. Frankland, M.I.E.E. Mr. Frankland, whilst remaining a director of the company, is undertaking special duties at the Trafford Park Works of British Insulated Callender's (Submarine Cables), Ltd.

Contracts

THE BRITISH TRANSPORT COMMISSION has placed a contract with the Pressed Steel Company, Ltd., Cowley, Oxford, for 195 20-ton bulk grain vans. The vans are to be constructed at the firm's Linwood Works, Paisley, Scotland.

THE MINISTRY OF SUPPLY has recently placed orders, valued at approximately £105,000, with David Brown Tractors (Engineering), Ltd., for industrial wheeled tractors. These machines have been ordered on behalf of the Ministry of Civil Aviation, and will be used on United Kingdom airfields for general towing duties, including salvage operations.

THE ENGLISH ELECTRIC EXPORT AND TRADING COMPANY, Ltd., has received an order from the U.S. Army Corps of Engineers for two 68,000 nominal h.p., 128·6 r.p.m., vertical-shaft, single-runner, Francis water turbines for the Table Rock dam power station. The turbines will be suitable for operating at heads of 134ft to 228ft, the nominal head being 190ft. At 134ft head the output of each turbine is 44,000 h.p., and at 228ft it is 83,200 h.p. Delivery will start in August, 1956, and completion is due by September, 1957. The turbines will be made in England by the English Electric Company, Ltd.

SIMON-CARVES, Ltd., Stockport, has received from the Indian Iron and Steel Company, Ltd., through the International Construction Company, Ltd., of London, a contract for the building of two batteries of seventy-eight coke ovens each, together with by-product plants and coal and coke handling plants, at the Burnpur steel works in West Bengal. The total cost of the work will exceed £3,000,000. The new batteries will form an extension to an existing battery completed by Simon-Carves, Ltd., in 1950, and will add 3500 tons of dry coal per day to the carbonising capacity at the Burnpur works.

British Patent Specifications

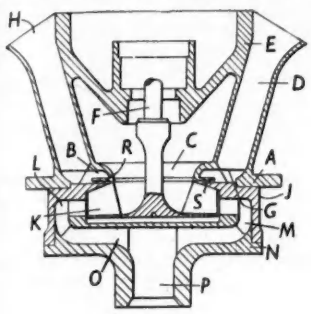
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

PUMPS

716,382. September 5, 1951.—Centrifugal Pumps, The Pulsometer Engineering Company, Ltd., and John Stanley Woodrow, both of Nine Elms Iron Works, Oxford Road, Reading, Berkshire.

The invention relates to centrifugal pumps suitable for pumping volatile or gas-containing liquids. The pump shown in the drawing is intended for mounting in the bottom of an aircraft fuel tank for pumping fuel. The pump casing consists of three main parts. An upper part comprises a flange *A* for



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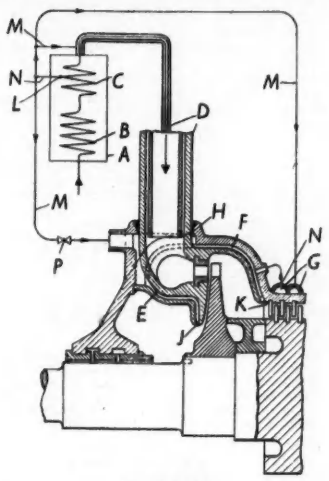
attachment to the base of the tank and is formed on its underside with an annular channel *B* surrounding a circular aperture which constitutes the inlet to the impeller eye *C*. Projecting up from the flange, above the annular channel, are two or three uniformly spaced escape conduits *D* which are inclined out by about 15 deg. Uniting these escape conduits near to their upper ends is a wall member *E* which supports the pump motor and a bearing for the impeller shaft *F*. The lower ends *G* of the escape conduits communicate with the annular channel *B* and their upper ends *H* are open. Secured to the underside of the upper member is a centre casing *J* which houses the impeller *K* and is provided around its periphery with diffuser passages *L* and an annular delivery passage or volute *M* into which the diffusers discharge. Fastened to the underside of the centre casing is a lower member *N* which is formed with a delivery chamber *O* communicating with the delivery passage *M* of the centre casing. The delivery chamber *O* is arranged to direct the flow of liquid radially inwards. An outlet passage *P* leads vertically down from the centre of this delivery chamber. The impeller is for the most part of orthodox construction and is arranged to rotate in the centre casing. However, in the upper wall of the centre casing bounding the impeller channels there is an annular escape aperture *R* which opens into the annular channel *B* and which is provided with radial vanes *S* for checking the rotation of the escaping fluids. In operation the pump will pump fuel from the fuel tank, the fuel entering the impeller through the spaces between the escape conduits *D*. The centrifugal and other hydrodynamic forces acting in the impeller channels will promote a separation of gas or vapour from the fuel, with the result that the fuel will lose its homogeneous character and will separate into a liquid phase and a gas or vapour phase. The bulk of the gas or vapour, and some of the liquid fuel, will escape from the impeller channels through the escape aperture *R* into the annular channel *B* and will then rise through the escape conduits *D* in the manner of a gas lift. The gas or vapour will discharge into the fuel tank well clear of the inflowing liquid fuel. A similar pump for delivering fuel from an aircraft fuel tank, mounted inside the fuel tank and suspended from it, is also shown in the specification.—*October* 6, 1954.

STEAM TURBINES

716,400. July 21, 1952.—Cooling the Steam-Conveying Parts of a High-Pressure Superheated Steam Turbine Plant, Aktiengesellschaft Brown, Boveri et Cie, Baden, Switzerland.

In the drawing *A* is the steam producer of a plant, *B* is an evaporator and *C* a superheater. A live steam pipe *D* is double walled. *E* is a cooling space or channel for the nozzle chamber of the turbine, and *F* is a cooling space or channel for the impeller chamber. If the turbine casing adjoining the impeller chamber has also to be cooled, this can be achieved by means of half tubes which are welded helically or otherwise—for instance, side by side, connected in parallel around the turbine casing—and thus form a double casing with cooling spaces or channels *G*. The cooling casings are provided with outlet openings at points *H*, *J* and *K*. The steam which emerges from opening *J* also serves to cool the rotor. The cooling steam is partially superheated. It is taken from a point, for instance *L*, which lies beyond the evaporator *B* and on the superheater *C*, where the steam has not



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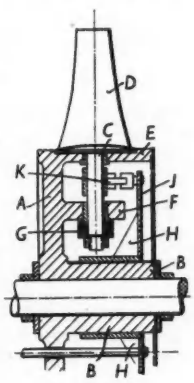
yet been superheated to the live steam temperature. The cooling steam is passed through pipes *M* to the cooling spaces of the parts to be cooled—that is to say, it passes to channels *E* and *F* and also to the channels *G*. From the inner channel *G* it goes into channel *F*, from where it goes (together with the cooling steam flowing directly through the channel) to the reaction blading of the turbine, passes through openings *H*, *J*, *K* and *N* in order to mix directly or indirectly again with the steam that flows through the turbine as stated. Connecting pipes *M* may be provided with valves such as indicated at *P*.—*October* 6, 1954.

TURBINES AND BLOWERS

716,389. January 17, 1952.—Axial-Flow Impellers and Rotors in Blowers and Turbines, Demag Aktiengesellschaft, Werthauser Strasse 64 (22*a*), Duisburg, Germany.

The invention relates to a method of securing the vanes or blades of the impellers or rotors of blowers and turbines, through which the medium flows in the axial direction. As the drawing shows the hub *A* of the impeller has the inner sleeve part *B* secured to the shaft. A pin *C* extends from the blade *D* through the outer rim *E* of the hub. Between the outer rim and the inner sleeve, and as closely as possible to the inner sleeve part *B*, there is also provided an intermediate rim *F*, through which the blade pins *C* extend. The pins are supported on the thrust bearings *G* in such manner that the intermediate rim *F* absorbs the centrifugal forces generated by the blades. On the inner part *B* of the hub there is provided an axially adjustable device *H*, which engages the pins *C* of the blades *D* through the disc *J* by means of levers *K*, thus determining the position of the blades. A modified construction is also shown and described in the specification.—*October* 6, 1954.



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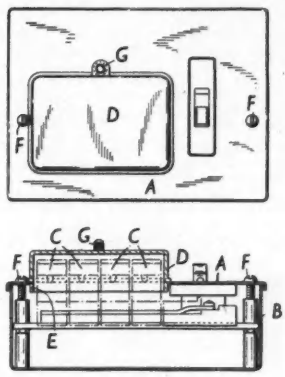
ELECTRICAL ENGINEERING

716,302. August 7, 1952.—Metal-Clad Electric Fuse Boards, George H. Scholes and Co., Ltd., Wylex Works, Wythenshawe, Manchester, and Frederick James Pearce, of the company's address.

The invention relates to metal-clad electric fuse boards or boxes where rewirable fuses are used. Its object is to provide simple means which enable the distance between the metal case and the fuse assemblies to be considerably reduced whilst effectively preventing flash over from a fuse to the case in the event of a severe short circuit. As will be seen from the drawing the lid *A* of the fuse box *B* in which are the fuse assemblies shown diagrammatically at *C*, has a cover *D* made of moulded plastic or other insulating material which sockets into the lid around the fuse elements, so that the part of the cover or its lip *E* which comes within and projects through the



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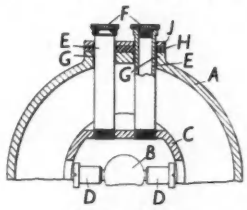
lid, forms a barrier which effectively prevents flash-over from said assemblies to the lid. The lid is secured to the box by screws *F* and the cover *D* is secured by a screw *G*.—*September* 29, 1954.

713,608. September 3, 1952.—Inspection of Brush Sparking in Dynamo-Electric Machines, James Russell Kennedy, 20, Upper Park Road, London, N.W.3, and Henry Leslie King, 17, Cleves Walk, Barkingside, Ilford, Essex.

The invention relates to improved means for the inspection of commutator and brushes of dynamo-electric machines. As shown in the drawing, *A* is



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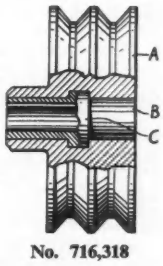
the casing of the machine, *B* is the commutator, *C* the cover of the commutator, *D* the brush holder, and *E* the tubular interconnections between the machine casing and the commutator cover. *F* are removable transparent plugs made of "Perspex." To avoid stressing of the machine, gaps *G* are left between the tubular members and the machine casing, and in order to ensure a fluid-tight connection a soft rubber gasket *H* is provided around the tubular members between the machine casing and a tube plate *J*. According to a modification, instead of using metal tubes screwed at one end into the commutator cover and provided at the other end with removable transparent plugs, solid cylindrical bars of "Perspex" or like material knurled at one end and threaded at the other end for screwing into the commutator cover may be employed. The rods may be arranged diametrically opposite each other, which has the advantage that the trailing edge of each brush can be sighted, or one single tube or transparent bar can be used in the centre.—*August* 11, 1954.

POWER TRANSMISSION

716,318. June 9, 1951.—Wheels and Pulleys, Moore and Scholes (Engineers and Founders), Ltd., Gillibrand Street, Walton-le-Dale, Preston. (*Inventor: Willie Moore.*)

The invention relates to wheels, pulleys, or the like and consists in casting the body portion of the pulley from aluminium or aluminium alloy on a cast iron, steel, gun metal, phosphor bronze, or other metal centre. By casting a pulley on a centre all machining is dispensed with, with the exception of the formation of the hole for the shaft and the formation of splines, keyways, or tapped holes for fixing purposes. The drawing shows in section a pulley made in accordance with this invention with a centre *B*, and a body portion *A* cast upon it. In this example the centre is formed with an enlarged portion *C*, which permanently retains the two parts of the pulley together.—*October* 6, 1954.



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Launches and Trial Trips

ATHELMERE, oil tanker; built by Hawthorn, Leslie (Shipbuilders), Ltd., for the Athel Line, Ltd.; length overall 459ft, breadth moulded 61ft, depth moulded 31ft, deadweight 10,000 tons; twenty main cargo oil tanks and twelve summer tanks, four main and four summer tanks fitted to take aqua ammonia, one main cargo oil pump room, two pumps, steam deck machinery, two 100kW diesel-driven generators and one 50kW steam-driven generator; Hawthorn-Doxford oil engine, four cylinders 670mm diameter by 2320mm combined stroke, 4450 b.h.p. at 112 r.p.m., two cylindrical boilers. Trial, October 12th and 13th.

GRANBY QUEEN, trawler; built by John Lewis and Sons, Ltd., for Talisman Trawlers, Ltd.; length overall 113ft 6in, length between perpendiculars 100ft, breadth moulded 20ft, depth moulded 10ft 9in; one 15kW diesel-driven generator, one 10kW belt-driven generator; Crossley Mark H.R.N.6 diesel engine, 440 b.h.p. at 300 r.p.m. Trial, October 14th.

OWERRI, cargo ship; built by Harland and Wolff, Ltd., Belfast, for Elder Dempster Lines, Ltd.; length overall 450ft, length between perpendiculars 425ft, breadth moulded 62ft, depth moulded to shelter deck 34ft, gross tonnage about 6200; twelve passengers; two steel decks, eight watertight compartments, four main cargo holds; seventeen derricks of 3 tons to 12 tons lift, one 30-ton and one 50-ton derricks, electric deck machinery, four 125kW diesel-driven generators; Harland and Wolff - B. and W. two-stroke, single-acting, opposed-piston diesel engine, five cylinders, 620mm diameter by 1870mm combined stroke. Launch, October 14th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BELFAST ASSOCIATION OF ENGINEERS

Wed., Nov. 17th.—College of Technology, Belfast, "Instruments and Automatic Control in the Boiler House," S. R. Halsey and J. H. Whitaker, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Nov. 17th.—S. WALES SECTION: College of Technology, Cathays Park, Cardiff, "The Techniques of Power Measurements from D.C. to 5 Mc/s," G. F. Lawrence, 6.30 p.m.

Tues., Nov. 30th.—N.W. SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, "Electronics and the Wind Tunnel," G. J. Scoles, 7 p.m.

CHEMICAL SOCIETY

Thurs., Nov. 18th.—Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7 "Molecular Rearrangements," M. J. S. Dewar, 7.30 p.m.

DIESEL ENGINE USERS ASSOCIATION

Thurs., Nov. 18th.—Caxton Hall, Westminster, London, S.W.1; "Notes on the Performance of Some Two-Stroke Oil Engines," S. J. Davies and M. A. Plint, 2.30 p.m.

ENGINEERS' GUILD

Wed., Nov. 17th.—METROPOLITAN BRANCH: Caxton Hall, Westminster, London, S.W.1, Films, "Power Progress," "Britain's 'Comet,'" and "Men Against the Sea," 6 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Nov. 23rd.—Church Institute, Hull, "Synthetic Rubbers," F. A. Jones, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., Nov. 16th.—GLOUCESTER AND CHELTENHAM CENTRE: General Electric Co., Ltd., 2, St. Aldate Street, Gloucester, "Lighting for Enjoyment," T. O. Freeth, 6.30 p.m.——LIVERPOOL CENTRE: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Lighting for Production," J. W. Howell, 6.30 p.m.

Wed., Nov. 17th.—LEEDS CENTRE: E.L.M.A. Lighting Service Bureau, 24, Aire Street, Leeds, 1, "Industrial Colour-Matching Problems," A. Wilcock, 6.15 p.m.——N. LANCASHIRE GROUP: N.W. Electricity Board, 19, Friargate, Preston, "The Sense of Sight," S. Mountain, 7.15 p.m.——TEES-SIDE GROUP: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Lighting Aids for Marine Navigation," K. C. Sutton-Jones, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Nov. 16th.—S. WALES BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, "Instrumentation and Thermostatic Controls," 7.15 p.m.

Wed., Nov. 17th.—GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "Assembly, Use and Maintenance of Chain Slings," W. G. Biggart, 7 p.m.——KENT BRANCH: Bull Hotel, Rochester, "Fan Characteristics with Particular Reference to their Application to Boiler Plant," C. E. Knight, 7 p.m.

Thurs., Nov. 18th.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "Gas Turbines," J. R. Needham, 7.30 p.m.——MERSEYSIDE AND N. WALES BRANCH: Radiant House, Bold Street, Liverpool, "The Factory Act and the Plant Engineer," A. Mills, 7.15 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Nov. 16th.—E. ANGLIAN SECTION: Central Hall, Public Library, Ipswich, "Gadgets," 7.30 p.m.

Wed., Nov. 17th.—LONDON BRANCH: Waldorf Hotel, Aldwych, London, W.C.2, "Some Foundry Problems," G. Rogers, 7.30 p.m.

INSTITUTE OF FUEL

Tues., Nov. 16th.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Modern Gas Turbine Practice," H. Farrington, 6 p.m.

Wed., Nov. 17th.—YORKSHIRE SECTION: Royal Victoria Station Hotel, Sheffield, "Flame Radiation Research," M. W. Thring, 2.30 p.m.

INSTITUTE OF MARINE ENGINEERS

To-day, Nov. 12th.—JUNIOR LECTURE, N.E. COAST SECTION: Technical College, Sunderland, "Marine Closed Feed Systems," D. C. Hagen, 4 p.m.

Tues., Nov. 16th.—SCOTTISH SECTION: The Lorne, Blackhall Street, Greenock, "Diesel Hydraulic Propulsion," F. J. Mayor, 7.30 p.m.

Wed., Nov. 17th.—JUNIOR LECTURE, MERSEYSIDE AND N.W. SECTION: Technical College, Birkenhead, "Marine Diesel Engines," A. G. Arnold, 7 p.m.

Thurs., Nov. 18th.—Royal Hotel, Bristol, Meeting for the Inaugurating of the West of England Section, 7 p.m.

Thurs., Nov. 25th.—N.E. COAST SECTION: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Automatic Boiler Controls," Ll. Young, 6.15 p.m.

INSTITUTE OF METALS

Thurs. and Fri., Nov. 25th and 26th.—4, Grosvenor Gardens, London, S.W.1, Meeting for the benefit of Members unable to take part in the Autumn Meeting in Switzerland. Thurs., 2.30 p.m., Discussion on "The Constitution of Titanium Alloys"; Fri., 10 a.m., Discussion on "Preferred Orientation"; Fri., 2.30 p.m., Discussion on "Corrosion and Staining of Aluminium Alloys."

INSTITUTE OF PETROLEUM

Wed., Nov. 17th.—Royal Institution, Albemarle Street, London, W.1, The Cadman Lecture, C. A. P. Southwell, 5.30 p.m.

INSTITUTE OF PHYSICS

Tues., Nov. 23rd.—NON-DESTRUCTIVE TESTING GROUP: Lecture Theatre, New Horticultural Hall, Vincent Square, London, S.W.1, Discussion on "The Fundamentals of Radiographic Definition, Resolution and Unsharpness," opened by R. Halmshaw and G. Spiegler, 2 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Nov. 25th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "The Use of Heat Pumps of Small Capacity for Various Purposes in Great Britain," M. V. Griffith, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., Nov. 17th.—N.W. CENTRE: Adelphi Hotel, Liverpool· "Disc Brakes," 7.30 p.m.

Thurs., Nov. 18th.—LONDON CENTRE: Royal Society of Arts, John Adam Street, London, W.C.2, "An Approach to the Organisation and Operation of a Large Composite Fleet," R. H. Patman, 6.30 p.m.——YORKSHIRE CENTRE: Hotel Metropole, King Street, Leeds, 1, "The Development and Operation of Disc Brakes," T. J. Phipps, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

To-day, Nov. 12th.—LONDON GRADUATES' AND STUDENTS' SECTION: Caxton Hall, Westminster, London, S.W.1, "Feed Back in Chemical Engineering Processes," F. F. Ross, 6.30 p.m.

Tues., Nov. 16th.—Science Museum, London, S.W.7, "Gas Refrigerating Machines," J. L. W. Kohler, 4.30 p.m.

Wed., Nov. 17th.—GRADUATES' AND STUDENTS' SECTION, MIDLANDS CENTRE: The University, Edmund Street, Birmingham, "Legal Aspects of Chemical Engineering," S. J. Green, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 16th.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, "Present Trends in the Design of Pressure Tunnels and Shafts for Underground Hydro-Electric Power Stations," Charles Jaeger, 5.30 p.m.

Wed., Nov. 17th.—MIDLANDS ASSOCIATION: Old College, Loughborough, "Prestressed Concrete in Practice," J. Singleton Green, 7 p.m.

Tues., Nov. 23rd.—RAILWAY MEETING: Great George Street, Westminster, London, S.W.1, "Standardisation of Type and Design Applied to Steam Locomotive Shed Roofs," V. F. Beer; "Smoke Extraction from Engine Sheds: An Account of Some Full-Scale Tests," R. L. McIlmoyle and D. W. Peacock, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Nov. 15th.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "Has Nuclear Fission a Future as a Source of Industrial Power," opened by Sir Harold Roxbee COX, 5.30 p.m.

Tues., Nov. 16th.—LONDON STUDENTS' SECTION: Public Library, Chelmsford, "Automatic Control of Electrical Machines," R. Molloy, 7 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Measurements of the Winding Resistance of a 132kV Power Transformer in Service," K. J. R. Wilkinson and J. D. Harmer, 6.30 p.m.——Savoy Place, London, W.C.2, "Celebration of the Jubilee of the Thermionic Valve," The Most Honourable the Marquess of Salisbury, K.G., P.C., Lord President of the Council, Opening Address, followed by "The Genesis of the Thermionic Valve," G. W. O. Howe, 2.30 p.m.; "Thermionic Devices from the Development of the Triode up to 1939," Sir Edward Appleton, 3.30 p.m.; Tea Interval, 4.30 p.m.; "Developments in Thermionic Devices Since 1939," J. Thomson, 5.30 p.m.

Thurs., Nov. 18th.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "The Use of Electricity in the Production of Calcium Carbide," C. J. Beavis, 5.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., Nov. 17th.—WOLVERHAMPTON BRANCH: Compton Grange, Compton Road, Wolverhampton, "Shell Moulding," with a Demonstration by M. C. Dixon and R. S. Bushell, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 16th.—39, Elmbank Crescent, Glasgow, "The Choice of Electrodes for Ship Welding," G. Zoethout, 7.30 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Tues., Nov. 16th.—Magnet House, Kingsway, London, W.C.2, "Application of Lifts for Modern Traffic Conditions," W. A Dixie, 6.15 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Nov. 17th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "A Modern Hydraulic Drive for Locomotives," R. H. Fett, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 12th.—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, "Inspection, Explosion and Breakdown of Boilers and Pressure Vessels," J. Eyers, 5.30 p.m.

Mon., Nov. 15th.—SCOTTISH A.D. CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Problems in the Design of an Economical Automobile Gearbox," T. C. F. Stott, 7.30 p.m.

Tues., Nov. 16th.—HYDRAULICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Measurement of Flow," 6.45 p.m.——E. MIDLANDS GRADUATES' SECTION: Schofield Buildings, Loughborough College, Loughborough, "Servo-Control," P. J. Bhatt, 7.15 p.m.

Wed., Nov. 17th.—E. MIDLANDS BRANCH: College of Technology, Chesterfield, "Nodular Cast Iron: Its Present Position and Future Prospects as an Engineering Material," S. B. Bailey, 7.30 p.m.——SOUTHERN BRANCH: Technical College, Brighton, Discussion on "The Future of the Compression-Ignition Engine for Small Road Vehicles," J. H. Pitchford, 7 p.m.——N.E. A.D. CENTRE: Chemistry Lecture Theatre, The University, Leeds, "Earth Moving," R. W. Ladbrooke, 7.30 p.m.——WESTERN GRADUATE SECTION: Grand Hotel, Bristol, "The Design and Construction of Locomotive Boilers," G. D. Gimlett, 7.15 p.m.

Thurs., Nov. 18th.—LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Expansion Provision for Pipelines," V. Westerman, 6.30 p.m.——SCOTTISH GRADUATES' SECTION: Y.M.C.A., 4, Queen Street, Edinburgh, "Peat-Fired Gas Turbines," Wm. Connell, 7.30 p.m.

Fri., Nov. 19th.—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, James Clayton Lecture, "Guided Missiles," G. W. H. Gardner, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Nov. 15th.—DERBY SECTION: College of Art, Green Lane, Derby, "Mechanical Accountancy," also Film, "Figures at Work," E. S. Carden, 7 p.m.——MANCHESTER SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "The Practical Application of Production Engineering Research," D. F. Galloway, 7.15 p.m.——N.E. SECTION: Neville Hall, Newcastle upon Tyne, "The Practical Uses of Electronics in Industry," K. A. Zandstra, 7 p.m.——STOKE-ON-TRENT SECTION: Blue Room, Mechanics Institution, Crewe, "Maintenance and the Production Engineer," A. J. Macintyre, 7.15 p.m.

Tues., Nov. 16th.—COVENTRY SECTION: The Craven Arms, High Street, Coventry, "The Design of Transfer Machines under Application to Production," H. W. Holbeche and F. Griffiths, 7 p.m.

Wed., Nov. 17th.—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Production and Properties of Titanium and Titanium Alloys," R. L. P. Berry, 7 p.m.——LIVERPOOL SECTION: Exchange Hotel, Liverpool, "Shell Moulding," D. N. Buttrey, 7.30 p.m.——LONDON GRADUATES' SECTION: 10, Chesterfield Street, London, W.1, "Use of Mechanical and Electronic Equipment for Production Planning and Control," E. F. Carden, 7.15 p.m.

Thurs., Nov. 18th.—CORNWALL SECTION: Technical College, Trevenson, Pool, Redruth, Discussion on "What Subjects should be Studies in Production Engineering Training," 7.15 p.m.——GLASGOW SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Basic Nomenclature of Cutting Tools," G. V. Stabler, 7.30 p.m.——SOUTHERN SECTION: "Provocative Tooling Methods for Aircraft," S. P. Woodley, 7.15 p.m.

Fri., Nov. 19th.—W. WALES SECTION: Central Library, Alexandra Road, Swansea, "Designing for Production," C. L. Boult, 7.30 p.m.

INSTITUTION OF SANITARY ENGINEERS

Mon., Nov. 15th.—Public Works and Municipal Services Congress, Olympia, London, "Practical Aspects of the Planning and Construction of Sewerage Schemes," W. D. Haworth, 3.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Nov. 12th.—WESTERN COUNTIES BRANCH: University Geology Lecture Theatre, Bristol, "Unusual Industrial Structures," H. C. Husband, 6 p.m.

Tues., Nov. 16th.—MIDLAND COUNTIES BRANCH: Supper Room, The King's Hall, Derby, "The Construction of a Prestressed Concrete Gas Holder Tank at Cromer," E. Williams, 7 p.m.——WALES AND MONMOUTHSHIRE BRANCH: S. Wales Institute of Engineers, Cardiff, "Economics in Welding Design," F. Brooksbank, 6.30 p.m.

Wed., Nov. 17th.—SCOTTISH BRANCH: Institution of Engineers and Shipbuilders, Glasgow, "The influence of Welding on Steel Building Structures," S. M. Reisser, 7 p.m.

IRON AND STEEL INSTITUTE

Wed. and Thurs., Nov. 17th and 18th.—4, Grosvenor Gardens, London, S.W.1, Autumn General Meeting.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 12th.—ORDINARY MEETING: Pepys House, 14, Rochester Row, London, S.W.1, "Corrosion," W. F. Gerrard, 7 p.m.

Fri., Nov. 19th.—Pepys House, 14, Rochester Row, London, S.W.1, Chairman's Address, "Engineering Plant in Buildings," S. G. Clark, 7 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Nov. 18th.—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "The Fracture of Metals," C. E. Phillips, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Nov. 12th.—Engineers' Club, Albert Square, Manchester, 2, "A Brief Survey of the Early History of Woolwich Arsenal," O. F. G. Hogg, 6.45 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., Nov. 18th.—Wigan and District Mining and Technical College, Wigan, "Colliery Management," Sir Andrew M. Bryan, 3 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Nov. 12th.—Mining Institute, Newcastle upon Tyne, "Instrumentation in Engineering Research with Particular Reference to Marine Turbine Machinery," B. J. Terrell, 6.15 p.m.

OLD CENTRALIANS

Mon., Nov. 15th.—Chez Auguste Restaurant, 47, Frith Street, London, W.1, "Standardisation and its Influence on Productivity," T. R. B. Sanders, 12.45 p.m.

REINFORCED CONCRETE ASSOCIATION

Wed., Nov. 17th, 11, Upper Belgrave Street, London, S.W.1, "Composite Construction," Felix J. Samuely, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Nov. 16th.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "Uses of the 'Ace' Computer," E. T. Goodwin, 7 p.m.

Wed., Nov. 17th.—GRADUATES' AND STUDENTS' SECTION LECTURE: 4, Hamilton Place, London, W.1, "Bird Flight and the Aeroplane," J. L. Pritchard, 7.30 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., Nov. 17th.—49, Cromwell Road, South Kensington, London, S.W.7, Discussion Meeting on "Water Supply," 4.45 p.m.

ROYAL SOCIETY OF ARTS

Wed., Nov. 17th.—E. FRANKLAND ARMSTRONG MEMORIAL LECTURE: John Adam Street, Adelphi, London, W.C.2, "Science and Food Production," Leslie H. Lampitt, 2.30 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Tues., Nov. 16th.—B.I.S.R.A., Hoyle Street, Sheffield, "Specifications: Friends or Foes?" S. Barraclough, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

To-day, Nov. 12th.—Technical College, Tavistock Road, Plymouth, Joint Meeting of the S.W. Section and the Corrosion Group, General Discussion of Practical Corrosion Problems, 3 p.m. to 4.45 p.m., and 5.30 p.m. to 7 p.m.

Thurs., Nov. 18th.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "The Constitution and Structure of Coal Tar Pitch," L. J. Wood, 6 p.m.

WOMEN'S ENGINEERING SOCIETY

Thurs., Nov. 18th.—LONDON BRANCH: Visit to Post Office Cable and Wireless Services, 6.45 p.m.